

TEMPERATURES OF NEAR SHORE ICEBERGS

IN THE ST. JOHN'S AREA

1983

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C-CORE

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1. INTRODUCTION

The temperature of glacial ice is a major factor in determining most of its other properties including physical, mechanical and electrical. The glaciers from which icebergs are calved may be as cold as -24°C or less (Diemand, 1983). After leaving their parent glaciers they may spend several years in Baffin Bay and its associated fjords. Since little or no ablation will take place while the bergs are in the cold water of Baffin Bay, the temperature of the outer layers of the ice will gradually rise to the ambient water temperature, about -1.8°C , resulting in a gradual temperature gradient from -1.8°C inward to the core temperature. After a year's residence in this cold water the temperature of the ice 15 m from the ice/water surface will be virtually undisturbed. When the icebergs drift south into the Labrador Sea and encounter warmer water this insulating outer layer will be eroded away. In water warmer than about 2° to 4°C this ablation rate will be more rapid than the thermal conduction so that the cold core of the ice will gradually approach the surface. This theory is discussed in greater detail in Diemand (1983).

This study was undertaken in part to test the hypothesis that the bulk temperature of iceberg ice will remain unchanged from that of its parent glacier due to the insulating quality of the ice itself. It was also hoped to discover the range of bulk temperatures to be expected in the iceberg population in Newfoundland water.

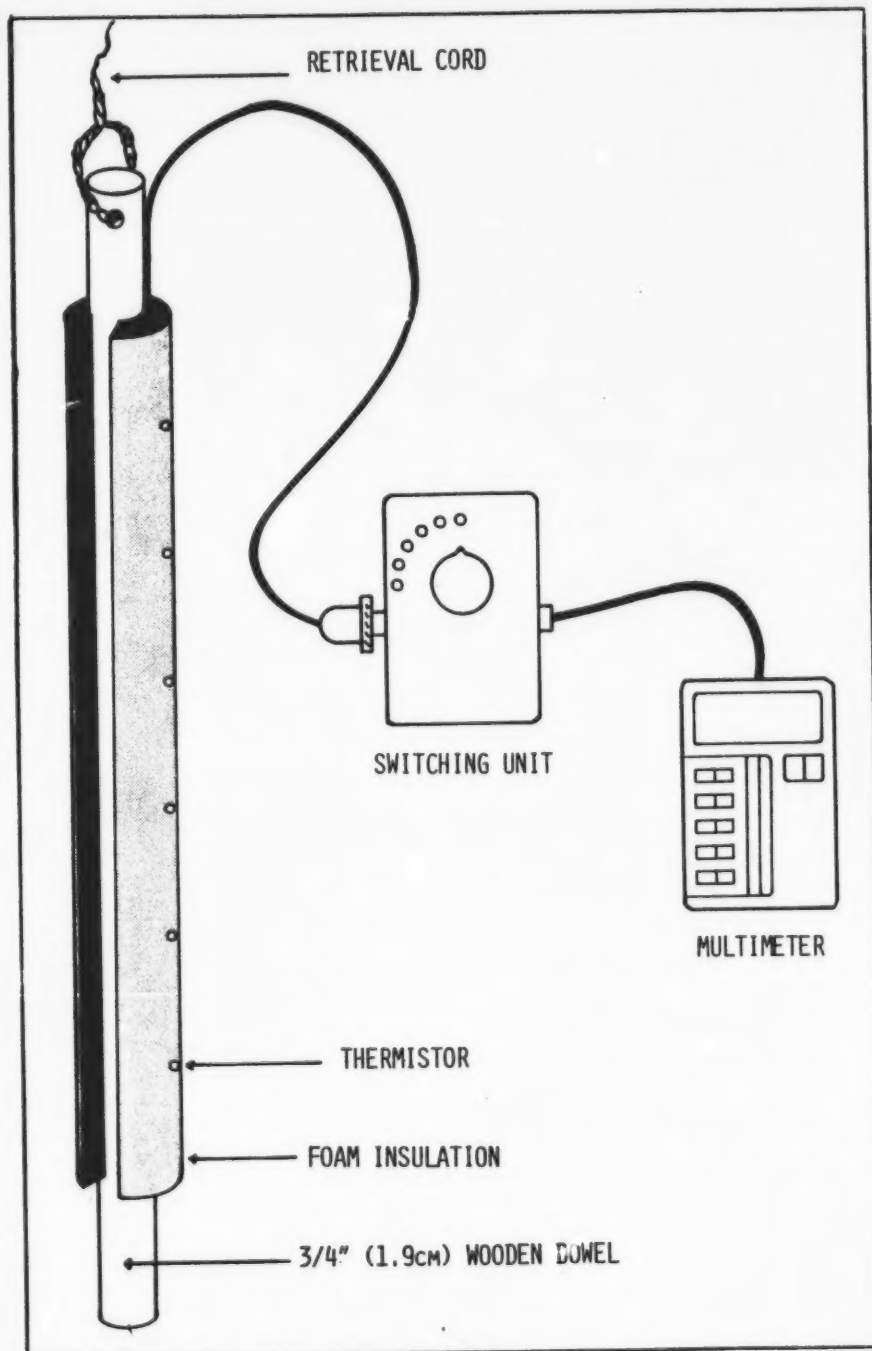


Figure 1 Borehole Probe

2. EQUIPMENT AND PROCEDURES

Temperature readings were obtained from auger holes in all cases. In most cases where thermal profiles were determined a 1 1/2" (3.8 cm) diameter ice auger with extensions was used. For shallow readings a 1" (2.5 cm) modified wood auger was used.

All readings were taken using YSI 44005 or 44007 thermistors. Resistance vs. temperature tables for these thermistors are given in Appendix D. Thermistor probes were of two types as shown in Figures 1 and 2.

The borehole probe (Fig. 1) was made so that it would fit snugly into a 3.8 cm auger hole, pressing the thermistors against the ice. The thermistors were set into aluminium pop rivets cut off to approximately the length of the thermistor. Omegatherm 201 thermally conductive paste was used to embed the thermistors in the pop rivets. The probes reached equilibrium in roughly 20 minutes.

The shallow probes (Fig. 2) had only one thermistor. It also was embedded in an aluminium pop rivet with Omegatherm 201. It was necessary to maintain pressure on the probe to obtain an accurate reading. This, however, was difficult over protracted periods due to motion of the boat and so equilibrium curves were not obtained.

Resistivity readings were taken using a hand-held DMM (Fluke Model 8020A or Hioki Model 3207). Temperatures were later calculated by direct interpolation.

Icebergs were boarded when possible. A helicopter was used for one tabular berg near St. John's early in the year. This was

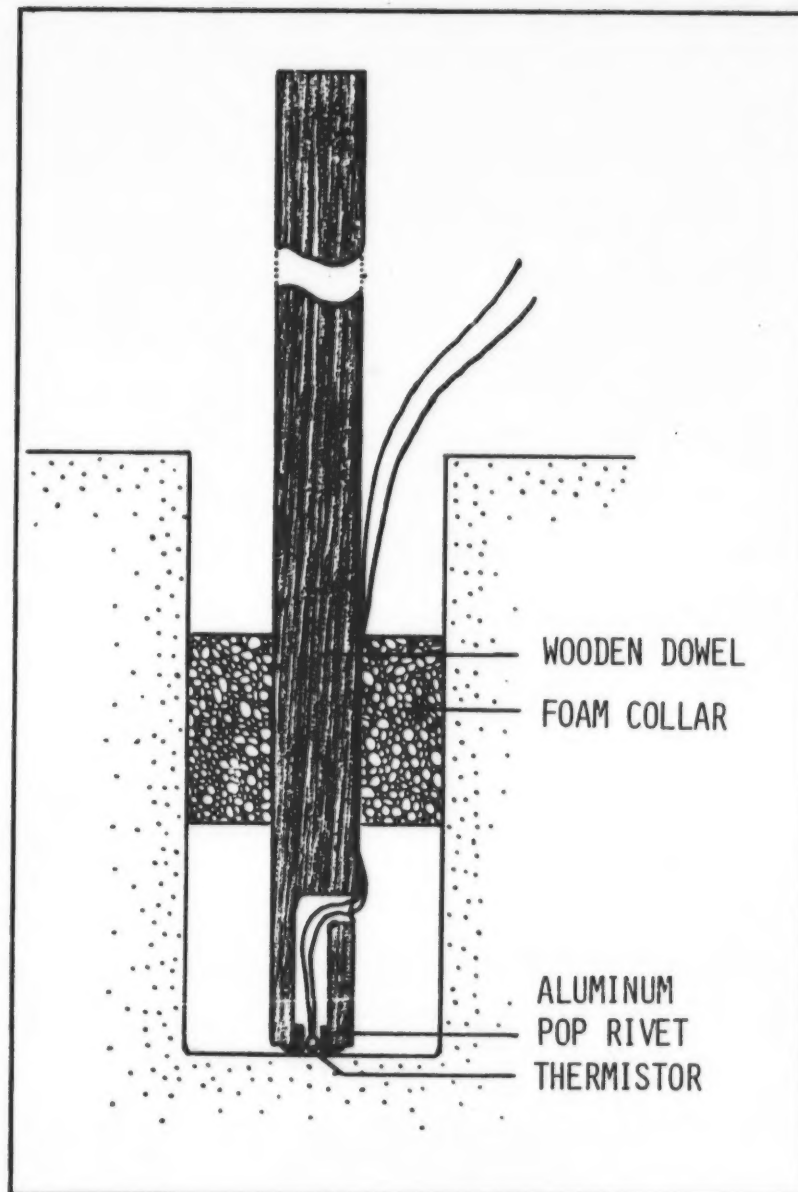


Figure 2 Shallow Probe

not practical for any of the other icebergs studied and inflatable boats or other small boats were used for the remainder of the work. As it is difficult and dangerous to approach an iceberg in rough seas, this was only attempted on calm days.

As meltwater was present on the surface of all bergs auger holes were made either on slightly raised areas or a channel was dug in the ice above the auger site to divert the meltwater away from the borehole. An auger hole was then made to the depth of the auger (1 metre) and the probe installed. While readings were being taken from the probe, a second hole was made nearby to the depth of the auger plus a one metre extension. After about 30 minutes the probe was transferred from the first to the second hole and readings were taken again for 30 minutes while the first hole was enlarged to a three metre depth. In this way except for the first metre segment, neither the probe nor the auger were exposed for any appreciable time to the relatively warm air temperatures. As time on the ice was limited it was not practical to remeasure this segment; the data suggest that the brunt of this warming may be absorbed by the top 30 cm.

When boarding was not possible, readings were obtained from the boat from shallow holes along the side of the berg. Holes were augered at an angle slightly upward from horizontal to prevent meltwater from running in.

Unless otherwise noted, water temperatures were taken either from METOC Sea Surface Temperature charts or from a manually operated bathythermograph. These data are noted in Appendix A.

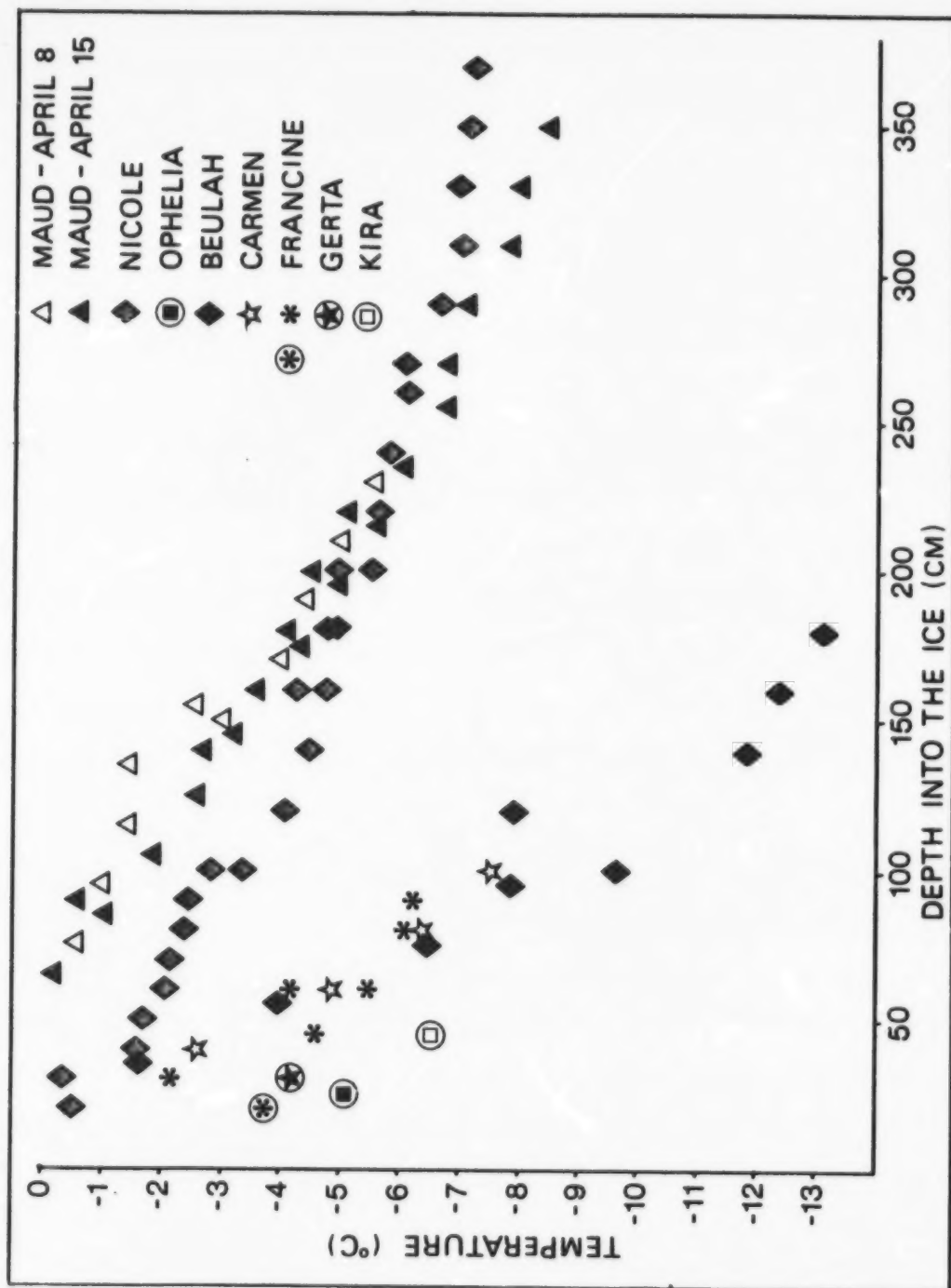


Figure 3 Composite of 1983 Field Season Data

3. RESULTS

Icebergs visited during the 1983 field season were designated as follows. All but two (Kira and Leona) were located in Conception Bay and shallow bays near St. John's.

Name	Date(s) Visited	Location	Surface Water
			Temperature (°C)
Maud	April 8 and 15	Freshwater Bay	< 0
Nicole	May 4	Freshwater Bay	2
Ophelia	May 14	Conception Bay	1 - 2
Beulah	May 20	Logy Bay	5 - 8
Carmen	June 10	Torbay	5
Dolores	June 10	St. John's	5
Francine	June 23 and 26	Spaniard's Bay	9 - 10
Gerta	June 23 and 26	Spaniard's Bay	9 - 10
Helen	June 24	Carbonear	8
Isobel	June 25	Adams Cove	8
Kira	July 3	Horse Chops	5 - 6
Leona	July 3	Horse Chops	5 - 6

Information on each individual berg is given in Appendix A along with data obtained from them.

Figure 3 is a composite of all data obtained in the 1983 field season. In general, data obtained near the surface of the ice were unreliable; one thermistor gave readings higher than 8°C and many suggested temperatures above the freezing point at

depths up to 30 cm into the ice. In all probability this is largely due to poor contact between the thermistor and the side of the auger hole as a result of enlargement of the hole from repeated withdrawals of the auger to clear the flights of snow. In some cases meltwater in the hole may have been a contributing factor.

It is clear, however, that as the season progresses and the surface water warms, the thermal gradient into the ice becomes increasingly abrupt. That is, the cold ice approaches the surface.

It may be argued that while a surface water temperature of 40C or greater will result in rapid deterioration of the ice, it will only affect the surface ice. Therefore, the thermal gradient over the greater part of the berg, that portion which is submerged at depths of 50 to 100 metres, will be virtually unchanged since water at these depths, on the whole will be much colder. However, all icebergs visited after April showed definite indications of having rolled at some time, and thus there is little likelihood that any significant part of the remaining ice has escaped contact with warm surface layers. In fact, this serial exposure to warm and cold water may explain the presence of seemingly gradual gradients, such as that found in Francine, in very warm water.

The only apparent anomaly in these data is the reading from Ophelia (Fig. 3), taken May 14, a week before the data from Beulah. One would expect that readings from this berg would lie to the right of those from Beulah rather than far to the left

among bergs in warm water. But this was a very small ice mass, about 30 metres wide and less than 10 metres high, which had been floating in the relatively protected water of Conception Bay for some time. Therefore most of its surface was above the thermocline and subject to the relatively high ablation rate caused by the 1-2° seawater. This is in contrast to the rest of the icebergs sampled which were large enough to penetrate the thermocline, so that a relatively large proportion of the ice was protected from melting.

It should also be noted that in no case was the bulk temperature of the ice obtained. That is, none of the temperature curves had reached steady state at the greatest depth measured. The coldest temperature obtained in this study was -13° at a depth of less than 2 m into Beulah in late May. However, it is clear that the temperature continued to drop below this depth and extrapolation of the curve suggests a possible minimum (bulk) temperature of -15°C to -20°C. In the case of Francine, however, the minimum temperature measured was slightly less than -6°C; the shape of the curve suggests that the bulk temperature was not much lower than this - perhaps in the neighbourhood of -7°C to -8°C, although the number of data points is insufficient to draw any firm conclusions.

It is important to consider that there may be local thermal disturbances within the ice caused by blue cracks or other factors which may give misleading results. For example, the curve obtained from Beulah has a very prominent discontinuity at a depth of about 120 cm. It is known that there was a narrow

blue crack (about 2 cm wide) roughly at this depth and a difference in the ice texture was discernible with the auger. The abruptness of this discontinuity suggests that this crack was formed very recently, perhaps within the previous month and was filled with water and healed while at sea.

Two interesting and related thermal phenomena were noticed in the course of this research. One is a form of exfoliation in which apparently shallow flakes are produced on a smooth side of an iceberg. On the average these flakes are in the order of a metre in length but may be considerably larger or smaller. On one occasion the formation of such a flake was observed accompanied by the rifle crack sound common in bergs in warm environments. This type of cracking was observed on Isobel and on Carmen covering most of one sheer face as well as at the waterline. It is possible that this exfoliation had occurred on other icebergs but was not noticed due to surface roughness, unfavourable lighting, ice opacity or other factors.

The other process may be viewed as an extreme example of exfoliation. It takes the form of delamination in which a relatively large volume of ice separates from the parent berg in a sheet following the contour of the ice surface (Fig. 4) and, presumably, separating along an isothermal layer. The depth of the layer lost by Beulah was about 60 cm and appeared to have been shed as a single unit. In the case of Dolores (Fig. 5), however, there appear to have been four layers probably shed at about the same time; the broken surface of the outer layer did not appear to have deteriorated appreciably more than those of

the inner ones. It seems likely that these exfoliation phenomena are caused by stresses induced by thermal expansion of the ice.

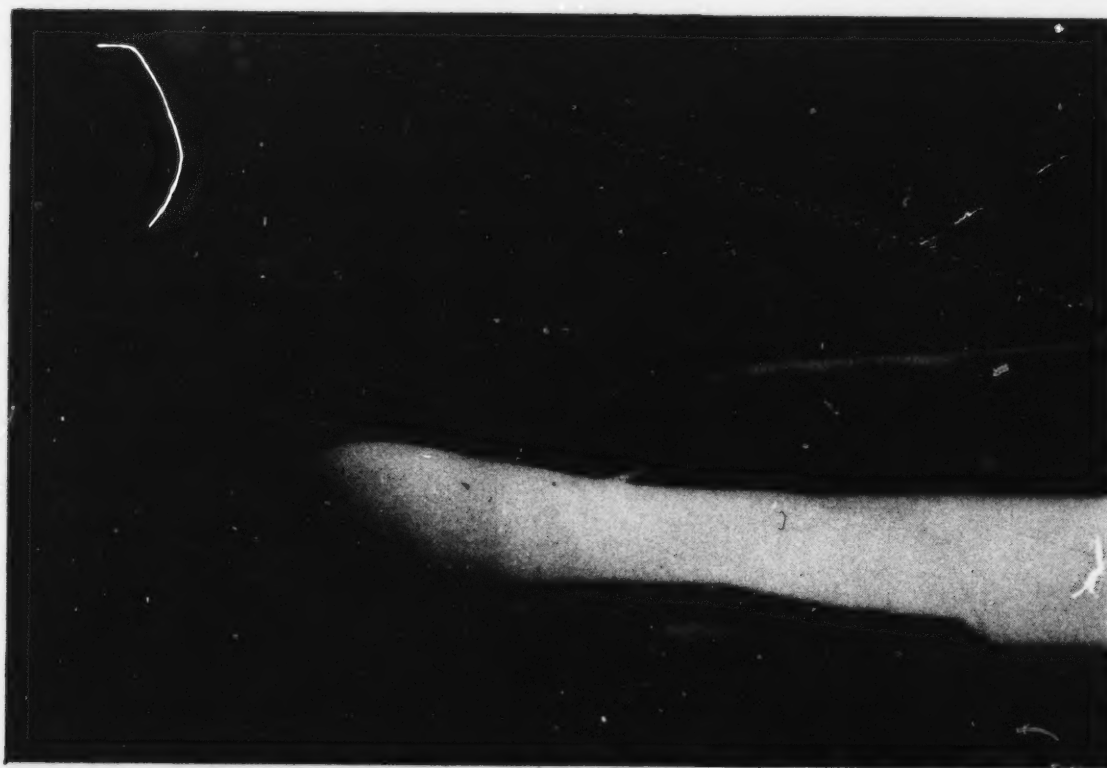


Figure 4 Iceberg Beulah - showing delamination at the water line

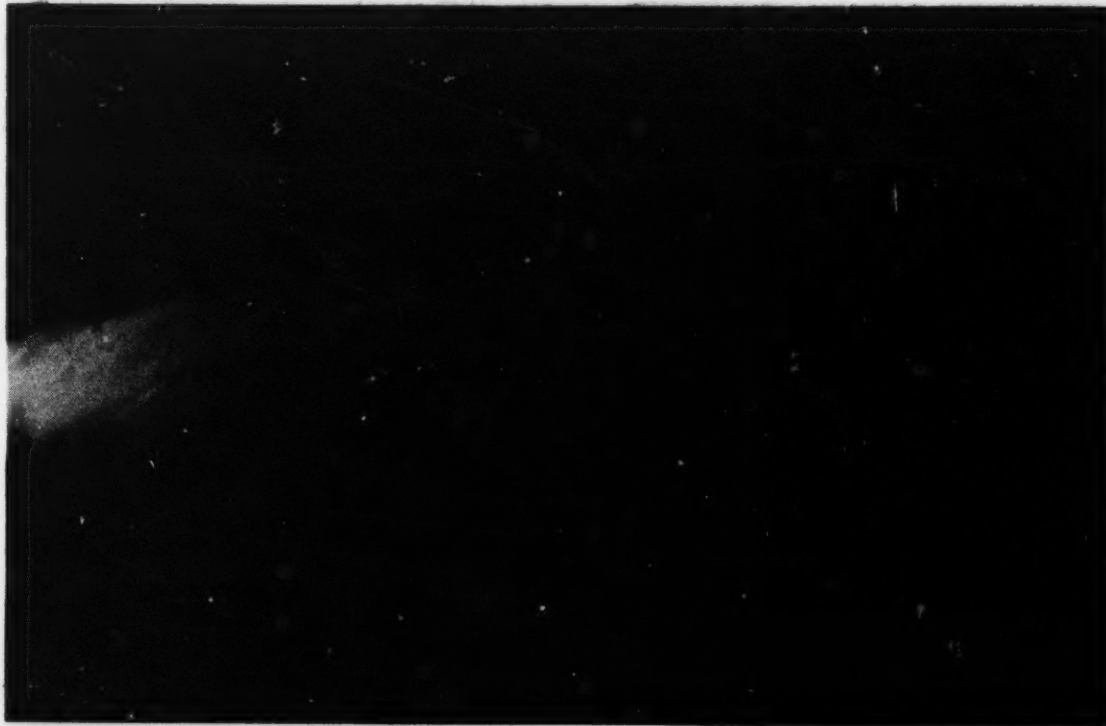


Figure 5 **Area of Delamination on Delores. Four separate layers can be discerned in the shaded region suggesting shedding along isothermal planes at four different times.**

4. CONCLUSIONS

It is clear that in general, icebergs will be colder near the surface as the seawater temperature rises. This suggests that temperature dependent properties of the ice, such as strength, hardness, and electrical properties, will be affected. This may result in very different ice property readings in southern bergs than in their northern counterparts.

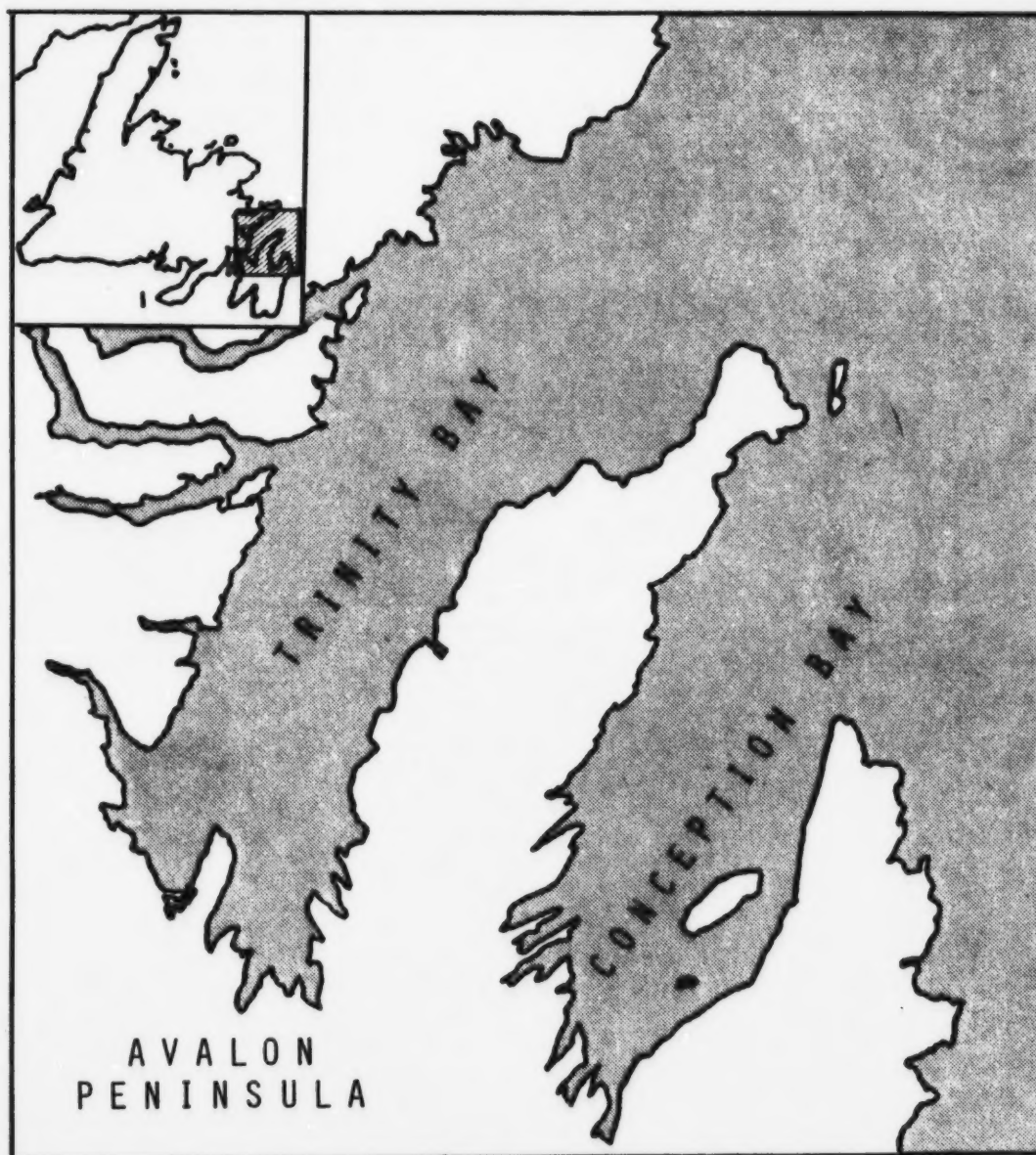
Furthermore, in areas along the Labrador shelf and others strongly influenced by the cold Labrador current, the thermocline is normally quite shallow and there a large proportion of a large iceberg will extend beneath the thermocline into water in which ablation will be suppressed. Small icebergs, however, will be more strongly affected by the warming of the surface layers since a larger proportion of their surface area will be above the thermocline. Thus, these smaller ice masses will represent uniformly cold, hard ice, suggesting that they may represent a greater hazard to floating structures than was previously thought.

Finally, it should be possible to fragment a large body of glacial ice by introducing a localized region of relative warmth (i.e. 0°C) into the cold core. The effect of thermal stress caused naturally by immersion in seawater was demonstrated by the localized delaminations of Beulah and Dolores. This phenomenon could be induced artificially by melting a heat source, such as a controlled thermit charge, into the ice. This capability could be extremely useful in the case of a large scouring berg approaching a vulnerable seabed structure.

REFERENCES

Diemand, D. (1983). Iceberg Temperatures - A Preliminary Report.
C-CORE Technical Report 83-5, April, 1983.

Appendix A
Icebergs Measured During 1983



Location map covering area in which icebergs measured in this study were located.



Maud

Description:

Tabular berg grounded in Freshwater Bay. 12-8 m freeboard with 63-75 m thickness measured by impulse radar with a possible maximum of 90 m. Surface dimensions 180 m x 120 m (roughly). These measurements were made on April 15.

Dates Visited:

April 8 and April 15.

On April 8 this berg was surrounded by pack ice. On April 15 the surface water temperature in the area was 0°C.

Maud was grounded in Freshwater Bay for something over a month. Our two visits were made by helicopter. During the intervening week the area experienced relatively warm temperatures and high winds. Due to the presence of pack ice though, the water temperature remained cold. The berg had not rolled, however, so readings on the two days were both from the original surface of this tabular iceberg. The heavy rains and warm temperatures experienced on April 12 and 13 probably are primarily responsible for the lower temperature on the second visit.

Maud

April 15	5 Min.		10 Min.		15 Min.		20 Min.		30 Min.	
	Res.	Temp.	Res.	Temp.	Res.	Temp.	Res.	Temp.	Res.	Temp.
	K	°C	K	°C	K	°C	K	°C	K	°C
10	9.23	1.17	8.54	2.72					8.95	1.78
30	8.92	1.85	8.61	2.56					9.27	1.09
50	8.07	3.84	8.39	3.01					9.37	0.88
70	9.25	1.13	9.36	0.90					9.62	0.36
90	9.51	0.59	9.51	0.59					10.08	-0.55
65	9.88	-0.16	9.95	-0.30			9.77	0.05	9.89	-0.18
85	10.03	-0.46	10.15	-0.69			10.31	-1.00	10.33	-1.04
105	10.41	-1.18	10.55	-1.44			10.75	-1.80	10.78	-1.85
125	10.90	-2.07	11.03	-2.29			11.17	-2.53	11.19	-2.57
145	11.34	-2.83	11.49	-3.09			11.52	-3.13	11.56	-3.20
140	11.26	-2.69	11.26	-2.69						
160	11.80	-3.59	11.76	-3.52						
180	12.18	-4.20	12.16	-4.17						
200	12.35	-4.46	12.36	-4.48						
220	12.78	-5.12	12.79	-5.13						
175	11.83	-3.64			12.02	-3.95			12.25	-4.31
195	11.99	-3.90			12.30	-4.38			12.64	-4.91
215	12.55	-4.77			12.84	-5.20			13.13	-5.62
235	12.72	-5.03			13.08	-5.55			13.42	-6.04
255	13.36	-5.96			13.65	-6.36			13.90	-6.70
270	13.37	-5.97	13.56	-6.23	13.69	-6.41			13.88	-6.67
290	13.54	-6.21	13.76	-6.50	13.95	-6.77			14.23	-7.14
310	14.13	-7.01	14.31	-7.24	14.48	-7.46			14.70	-7.74
330	14.03	-6.88	14.27	-7.19	14.51	-7.50			14.85	-7.93
350	14.66	-7.69	14.82	-7.90	15.01	-8.13			15.26	-8.44

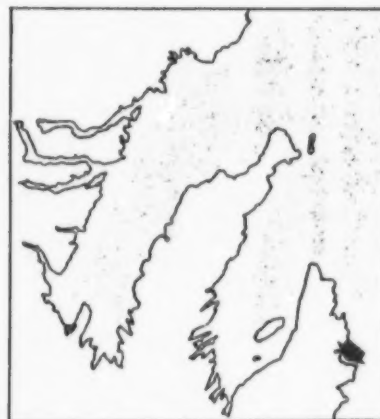
Depth into ice (cm)

Maud

April 8

	Res.	Temp.	
	K Ω	$^{\circ}\text{C}$	
15	8.68	2.4	
35	9.00	1.7	
55	9.55	0.5	readings after 45 minutes
75	9.80	0.0	
95	9.74	0.1	
75	10.09	-0.6	
95	10.32	-1.0	
115	10.55	-1.4	readings after 30 minutes
135	10.56	-1.4	
155	11.22	-2.6	
150	11.58	-3.0	
170	12.02	-4.0	
190	12.33	-4.4	readings after 1 hour
210	12.76	-5.0	
230	13.12	-5.6	

Depth into ice (cm)



Nicole

Description: Pinnacle berg grounded in Freshwater Bay. Maximum height approximately 20 m. Bisected by one large blue crack approximately 1 m wide. Other smaller ones were present.

Date Visited: May 4

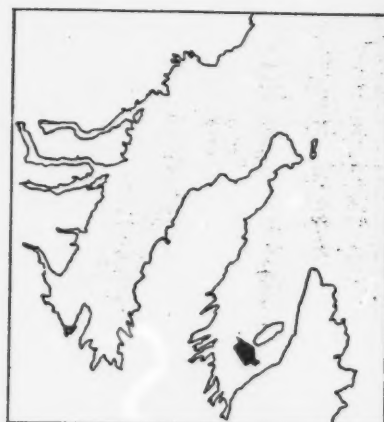
Water Temperature: Sea surface temperature had recently risen to about 20°C.

The 1 1/2" auger hole was made about 10 m from the large crack and as far as possible from the other smaller ones.

Mean air temperature during the week previous to our visit was in the vicinity of 9-10°C.

Nicole

	5 Min.		10 Min.		15 Min.		20 Min.		30 Min.	
	Res.	Temp.	Res.	Temp.	Res.	Temp.	Res.	Temp.	Res.	Temp.
	K Ω	$^{\circ}\text{C}$	K Ω	$^{\circ}\text{C}$	K Ω	$^{\circ}\text{C}$	K Ω	$^{\circ}\text{C}$	K Ω	$^{\circ}\text{C}$
0	9.50	0.61	9.46	0.69			9.38	0.86		
20	9.65	0.30	9.97	-0.34			10.06	-0.51		
40	10.37	-1.11	10.55	-1.44			10.66	-1.64		
60	10.49	-1.33	10.74	-1.78			10.89	-2.05		
80	10.53	-1.40	10.86	-2.00			11.08	-2.38		
100	10.77	-1.84	11.01	-2.26			11.33	-2.81		
10							9.15	1.35		
30							9.95	-0.30		
50							10.67	-1.65		
70							10.94	-2.14		
90							11.12	-2.45		
100	11.17	-2.53					11.55	-3.18	11.67	-3.38
120	11.65	-3.34					11.98	-3.89	12.08	-4.05
140	11.87	-3.70					12.25	-4.31	12.36	-4.48
160	12.17	-4.18					12.45	-4.62	12.53	-4.74
180	11.83	-3.64					12.29	-4.37	12.54	-4.75
200	11.33	-2.83					12.23	-4.28	12.66	-4.94
160	12.25	-4.31	12.13(?)	-4.12	12.21	-4.25				
180	12.65	-4.92	12.66	-4.94	12.67	-4.95				
200	12.92	-5.32	13.02	-5.46	13.05	-5.51				
220	12.96	-5.38	13.08	-5.55	13.12	-5.61				
240	13.04	-5.49	13.20	-5.72	13.26	-5.81				
260	13.32	-5.90	13.43	-6.05	13.48	-6.12				
270	13.04	-5.49	13.21	-5.74			13.44	-6.07		
290	13.55	-6.22	13.70	-6.42			13.87	-6.66		
310	13.82	-6.59	13.96	-6.78			14.11	-6.99		
330	13.72	-6.45	13.89	-6.68			14.09	-6.96		
350	13.88	-6.67	14.04	-6.89			14.23	-7.14		
370	13.84	-6.62	14.05	-6.90			14.28	-7.21		



Ophelia

Description:

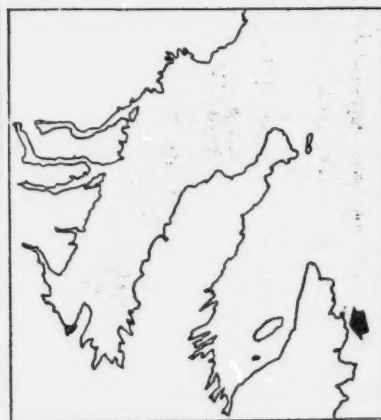
Small dry dock near Bell Island. The higher of the two peaks was roughly 15 m high with sheer sides. The lower side was roughly 10-12 m high and gradually sloping with severe undercutting on the seaward edges.

Date Visited: May 14

Water Temperature: Water temperature in the area was on average about 1.2°C.

A thermistor instrumented projectile was fired into a sheer face of the higher side at a location which appeared to have recently calved. The projectile penetrated the ice about 25 cm and gave a reading of -5.10°C (12.8 kΩ).

The lower side calved soon after this and a fragment was retrieved. The temperature obtained from a 10 cm hole bored into this fragment gave the same reading. Due to the thickness of the calved overhangs, it is not known how far from the berg's surface this fragment was located originally but it is unlikely to have been more than 1 m and was probably less.



Beulah

Description: Large pinnacle berg near Logy Bay. Maximum height about 30-35 m.

Date Visited: May 20

Water Temperature: Surface water temperature was about 5°C in the area and was measured at 8°C in the lee of the berg.

The complexion of the berg suggested that it had rolled to its current position recently and the augering site chosen had been submerged at a depth of 5-10 m.

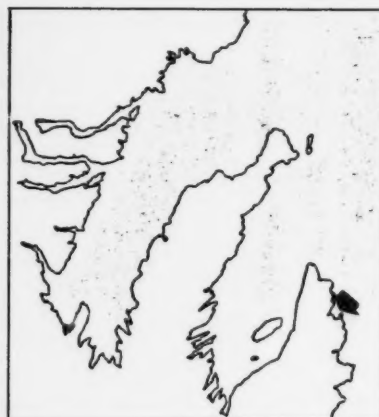
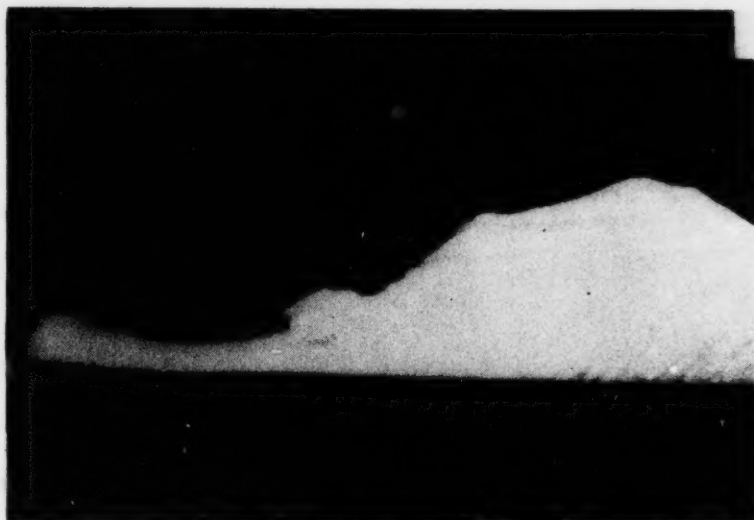
The ice chips generated while installing ice screws and carving runoff channels were extremely sharp and metallic sounding suggesting considerably lower temperatures at the surface than the readings suggested.

The foam insulation on the thermistor probe was damaged somewhat on removal from the ice after the first set of readings as it had frozen to the side of the hole in several places. Whether this was due to seepage of meltwater into the hole or to moisture on the probe when it was inserted into the hole is not known. The damage was not thought to be grave enough to affect further readings and therefore it was used to obtain the second set of readings. This time it was so badly frozen in that it was completely destroyed on removal.

Beulah

	5 Min.		10 Min.		15 Min.		20 Min.		25 Min.		30 Min.	
	Res.	Temp.	Res.	Temp.	Res.	Temp.	Res.	Temp.	Res.	Temp.	Res.	Temp.
	K Ω	°C	K Ω	°C	K Ω	°C	K Ω	°C	K Ω	°C	K Ω	°C
15	8.10	3.77	6.72	7.56	6.85	7.17	7.06	6.55			7.22	6.09
35	9.24	1.15	9.87	-0.14	10.29	-0.96	10.49	-1.33			10.67	-1.65
55	10.34	-1.05	10.86	-2.00	11.44	-3.00	11.74	-3.49			12.04	-3.98
75	11.94	-3.82	12.51	-4.71	13.13	-5.62	13.45	-6.08			13.74	-6.48
95	12.33	-4.43	13.79	-6.55	14.40	-7.36	14.61	-7.63			14.75	-7.81
100	14.55	-7.55	15.14	-8.29	15.37	-8.57	15.36	-8.56	15.46	- 8.68	16.29	-9.65
120	13.89	-6.68	12.06	-4.02	12.37	-4.49	12.76	-5.09	13.00	- 5.43	14.83	-7.91
140	14.19	-7.09	13.79	-6.55	13.81	-6.58	14.28	-7.21	15.24	- 8.41	18.31	-11.79
160	12.11	-4.09	13.03	-5.48	13.39	-6.00	14.73	-7.78	16.09	- 9.42	18.91	-12.37
180	12.27	-4.34	13.04	-5.49	15.09	-8.23	16.48	-9.86	17.43	-10.89	19.67	-13.08
200	15.33	-8.52	15.95	-9.26	17.01	-10.44	17.84	-11.31	18.61	-12.08	OPEN	

Depth into ice (cm)



Carmen

Description: Small pinnacle/dome near Torbay.

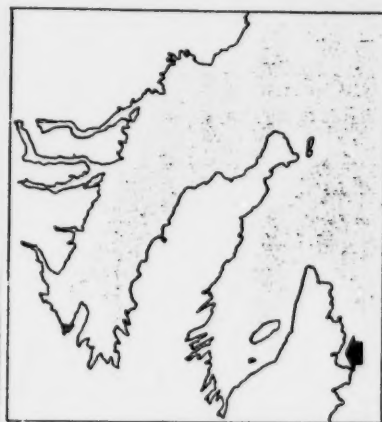
Date Visited: June 10

Water Temperature: About 5°C

Both the texture of the surface and the presence of well-formed underwater melt channels suggested that this berg had rolled within the past day or two. The augering site chosen was probably in the rapid ablation zone before the berg rolled. Maximum height was about 15-20 m. Considerable difficulty was encountered in augering this iceberg. The auger jammed repeatedly on the first hole and became irretrievably stuck on the second and had to be abandoned. This was probably due to the abundant meltwater pouring off the ice. It was very difficult to keep water out of the hole even with meltwater channels.

Carmen

	5 min.		10 min.		15 min.		20 min.		30 min.	
	Res.	Temp.	Res.	Temp.	Res.	Temp.	Res.	Temp.	Res.	Temp.
	KΩ	°C	KΩ	°C	KΩ	°C	KΩ	°C	KΩ	°C
0	8.73	2.28	8.69	2.37	6.43	8.47	6.59	7.96	6.50	8.24
20	9.02	1.63	9.10	1.46	9.28	1.07	9.46	0.69	9.56	0.49
40	10.24	-0.86	10.69	-1.69	10.90	-2.07	11.09	-2.40	11.20	-2.58
60	11.11	-2.43	11.71	-3.44	11.97	-3.87	12.39	-4.52	12.56	-4.78
80	12.24	-4.29	12.92	-5.32	13.17	-5.68	13.52	-6.18	13.68	-6.40
100	12.85	-5.22	13.76	-6.51	14.22	-7.13	14.74	-7.79	14.54	-7.53 ???



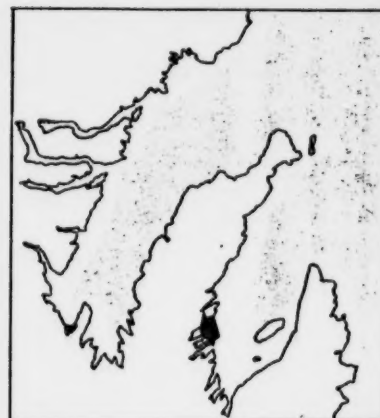
Delores

Description: Large pinnacle berg grounded outside St. John's harbour for about 4 months. Grounded in 100 m of water, height estimated by the Canadian Coast Guard, 50 m.

Date Visited: June 10

Water Temperature: approximately 50C

It was not possible to obtain temperature readings from this iceberg due to its exposed location and the prevalence of ocean swells in the area. However, it did offer a very interesting example of delamination (see text); the four layers were each about 20-30 cm thick.



Francine

Description: Pinnacle iceberg in Spaniard's Bay. This berg was about 15 m high at the peak and had a large melt pool contained by a low ledge at one end.

Dates Visited: June 23 and 26

Water Temperature: Water temperature in the area was about 9°-10°C. A thermal profile of the water was obtained using a manual bathythermograph.

	res	temp (°C)
1 m	6.10	9.56
3 m	6.27	8.98
6 m	6.45	8.41
9 m	7.04	6.61
12 m	7.40	5.60
15 m	7.54	5.21
30 m	7.74	4.69

A temperature reading was obtained from the ledge on June 23 in an area which appeared to have broken off fairly recently. The hole was 20 cm deep and measured 19.82 kΩ (-3.75°C). A shallow probe was used to obtain this reading.

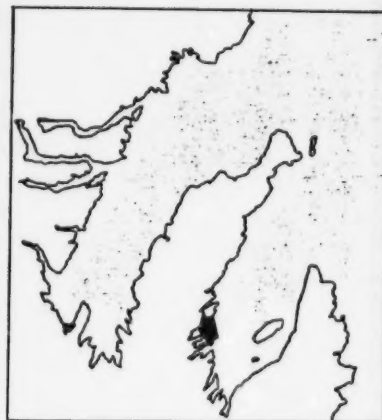
By June 26 the berg had rolled enough to empty the pool. An attempt was made to auger a 1 1/2" hole into a recently broken face on the high end. This attempt resulted in a nearby overhang

dropping into the water. One of the fragments of this dropped ice was floating such that the former surface of the ice was vertical in the water and the cleaved face was exposed. Shallow probes were used to obtain a thermal profile of this fragment. It was not possible to use holes nearer than 30 cm from the edge since this region was occasionally washed by small waves which filled the auger holes with seawater.

Francine

		res.	temp.
		K Ω	$^{\circ}\text{C}$
Depth into ice (cm)	30	18.30	-2.21
	45	20.7	-4.57
	60	12.20*	-4.23
	60	21.7	-5.46
	80	22.4	-6.07
	90	13.56*	-6.23

* YSI 44005
all others YSI 44007



Gerta

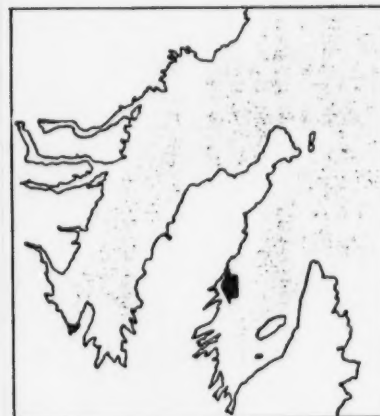
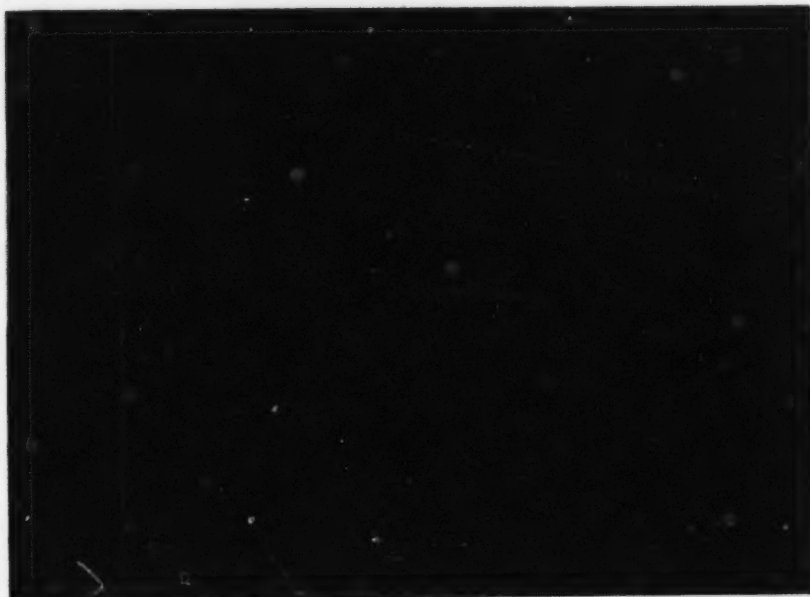
Description: Pinnacle/Dome berg in Spaniard's Bay

Dates Visited: June 23 and 26

Water Temperature: Water temperatures were the same as those for Francine, 9-10°C.

Our first effort, on June 23, to auger this berg was abandoned when the berg started to roll.

On our second visit, on June 26, two shallow holes were made. The first at 15 cm depth measured -0.59°C ($10.10\text{k}\Omega$) while the second at 30 cm measured -4.20° ($20.3\text{ k}\Omega$).



Helen

Description: Large pseudo-tabular iceberg near Carbonear.

Date Visited: June 24

Water Temperature: A thermal profile was taken of the water north (landward) of Helen. This profile is shown in the Table

Thermal Profile of Seawater Near Helen

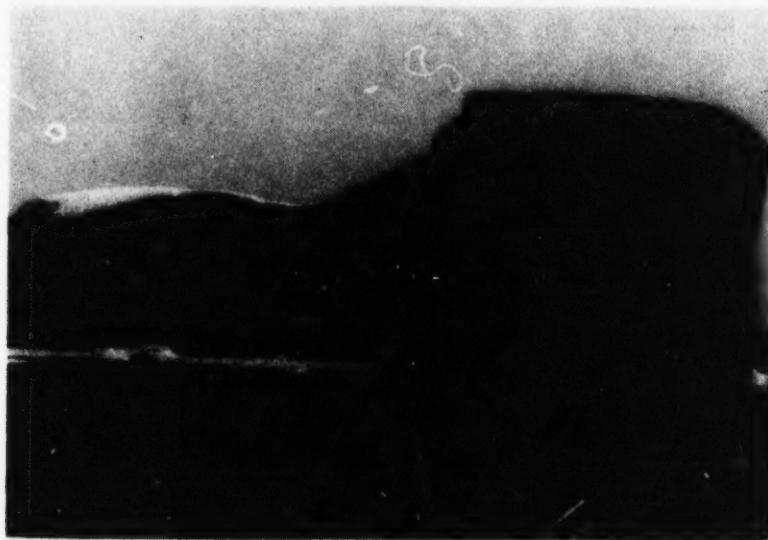
	Res. KΩ	Temp. °C
surface	6.35	8.72
3 m	6.85	7.18
6 m	7.08	6.50
9 m	7.21	6.12
12 m	7.43	5.51
15 m	7.56	5.16
21 m	9.05	1.57
30 m	10.09	-0.57
36 m	10.14	-0.67
42 m	10.34	-1.05
48 m	10.39	-1.14

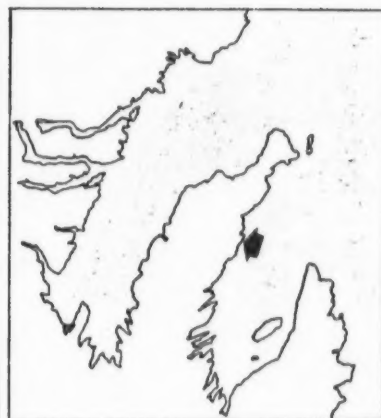
* This berg was interesting in that it appeared to be indisputably tabular from one side (see above); a sheer broken face ran the length of it and it had a more or less flat top surface. However, on one end of it there was a rounded weathered

lobe sloping down to the water which suggested a pinnacle configuration (see below). This lobe also contained a great deal of sediment, much of which was smeared down the face. The strata appeared to run in a vertical plane more or less parallel to the long axis of the berg.

Temperature measurements were obtained from a fragment which had been shed from one of the shear sides about 15 minutes before the measurements were taken. The growler was about 3-5 m in diameter. It is not known which, if any, of its surfaces had been at the surface of the iceberg. Therefore the depths noted represent only depths into the growler and not into the berg.

		5 min.		10 min.		20 min.	
Depth into ice		res	temp	res	temp	res	temp
		K Ω	$^{\circ}$ C	K Ω	$^{\circ}$ C	K Ω	$^{\circ}$ C
	5 cm	12.14	-4.29	14.24	-7.15		
	15 cm			27.5	-9.88	29.9	-11.4





Isobel

Description: Pinnacle berg in Adam's Cove with a long narrow foot. This berg was 10-15 m high at the peak.

Date Visited: June 25

While this berg was not actively calving it was audibly cracking fairly frequently. On one smooth area of its surface thermal exfoliation was clearly visible.



Kira and Leona

Description:

Kira (flat-topped) and Leona (pinnacle) were located very close to shore at Horsechops near Trinity. It is thought that the two had previously formed a single berg. Kira was about 3-5 m high and about 25-30 m in diameter. It was located less than 200 m from the shore. Leona was further from shore and considerably larger.

Date Visited: July 3

Water Temperature: Water temperature in the area was measured at about 5-6°C.

Both of these bergs were calving actively and were badly undercut in many places. Growlers were common in the area but due to a moderate swell which tended to swamp them, it was not possible to obtain temperature readings from them. One shallow hole was made on a recently calved face (with 15 minutes of the calving) about 50 cm from the upper surface of the berg. The temperature was -6.56°C (23.7 kΩ).

Appendix B
Weather Conditions
During the Study Period

These data are taken from the Monthly Meteorological Summary compiled and published by the Atmospheric Environment Service of Environment Canada.

MONTH/MOIS

APRIL / AVRIL

19 63

AT: A

ST. JOHN'S "A" (YYT) Nfld.

LAT		47 37' N		LONG 52 45' W		ELEVATION ALTITUDE 140		METRES (ASL) METRES (INMM)			
DATE	TEMPERATURE TEMPERATURE			PRECIPITATION PRECIPITATIONS			SNOW ON GROUND NEIGE AU SOL	WIND VENT			BRIGHT SUNSHINE INSOLATION EFFECTIVE
	MAXIMUM MAXIMALE	MINIMUM MINIMALE	MEAN MOYENNE	RAINFALL PLUIE (HAUTEUR)	SNOWFALL NEIGE (HAUTEUR)	TOTAL PRECIP. PRECIP. TOTALE		AVERAGE SPEED VITESSE MOYENNE	PREVAILING DIRECTION DIRECTION DOMINANTE	MAXIMUM SPEED AND DIRECTION VITESSE MAXIMALE ET DIRECTION	
	°C	°C	°C	mm	cm	mm		km/h		km/h	
1	1.6	-2.5	-0.5		TR	TR	0	19.0	SW	WSW 22	0.4
2	1.0	-1.8	-0.4	2.8	0.4	3.2	TR	17.3	ESE	ESE 26	0.0
3	2.2	-0.5	0.9	17.2	0	17.2	0	19.4	NNE	ENE 30	0.0
4	1.4	-0.4	0.5	4.2	0	4.2	0	24.6	NNE	NNE 30	0.0
5	1.6	0.0	0.3	5.4	0	5.4	0	30.8	ENE	ENE 41	0.0
6	1.8	-1.0	0.4	5.4	0	5.4	0	37.3	ENE	ENE 46	0.0
7	4.2	-4.0	0.1	0	0	0	0	19.2	NE	NE 35	10.1
8	9.6	-4.6	2.5	0	0	0	0	16.8	S	S 33	5.7
9	7.0	-2.3	2.4	4.0	0.8	4.4	0	32.0	S	WSW 50	2.5
10	-2.3	-10.4	-6.4	0	TR	TR	TR	34.4	NNW	N 57	10.1
11	-0.1	-11.0	-5.6	0	0	0	0	16.0	SSE	SSE 30	10.1
12	6.5	-1.5	2.5	22.0	0	22.0	0	44.9	S	SSE 65	0.9
13	10.0	-1.8	4.1	14.2	TR	14.2	0	24.9	SVRL	S 37	0.8
14	-0.8	-3.3	-2.1	0	0.4	0.4	TR	32.4	NNE	NE 46	0.0
15	1.6	-2.8	-0.6	0.8	0	0.8	0	20.4	SVRL	ENE 30	1.1
16	9.9	-0.4	4.8	1.0	0	1.0	0	7.2	E	ENE 11	0.0
17	6.5	3.0	4.8	0.6	0	0.6	0	13.3	SE	SE 20	0.0
18	7.0	2.8	4.9	10.6	0	10.6	0	27.9	SE	SE 46	0.0
19	12.4	3.0	7.7	0.4	0	0.4	0	10.0	ESE	ESE 19	0.0
20	11.4	3.8	7.6	27.6	0	27.6	0	15.0	ESE	E 33	0.0
21	19.6	4.9	12.3	0	0	0	0	12.4	SVRL	S 22	8.3
22	13.6	4.4	9.0	5.6	0	5.6	0	6.7	SVRL	SSE 15	0.0
23	14.5	4.0	9.3	1.8	0	1.3	0	11.0	WSW	WSW 14	8.5
24	6.6	1.0	3.8	4.8	0	4.8	0	10.3	N	N 20	0.0
25	9.4	1.0	5.7	0.4	0	0.4	0	6.5	SVRL	SE 11	0.0
26	13.8	4.5	9.2	0	0	0	0	14.4	SE	SE 19	0.8
27	10.0	4.5	7.3	0.2	0	0.2	0	23.7	SSE	SSE 59	0.0
28	11.7	4.8	8.3	6.2	0	6.2	0	24.6	SSE	SSE 33	0.0
29	16.8	3.6	10.2	0	0	0	0	28.8	WSW	WSW 56	11.2
30	17.2	6.5	11.9	0	0	0	0	31.8	WSW	WSW 46	7.2
31											
MEAN MOYENNE		7.5	0.1	3.8	135.2	1.6	136.4	21.1	PREVAILING DOMINANTE SSE	MAXIMUM SSE 65	TOTAL 71.8

Δ Indicates more than one occurrence of same speed but not necessarily same direction.

STANDARD TIME USED HEURE NORMALE UTILISEE N.S.T.																								
DRY-BULB TEMPERATURE SUMMARY * SOMMAIRE DES TEMPERATURES DU THERMOMETRE SEC*												MONTH MOIS APRIL / AVRIL 19 83												
Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	-13	-18	-18	-18	-22	-21	-19	-16	-12	-06	-04	-02	04	09	13	15	10	08	01	-05	-10	-15	-16	-18
2	-15	-17	-15	-12	-13	-11	-09	-03	-06	-04	01	04	09	06	02	-04	-02	-02	-02	-01	-02	-01	-01	-02
3	-03	-05	-08	-04	-01	00	01	03	05	12	16	20	19	18	20	16	15	13	12	08	02	04	04	04
4	06	08	05	04	09	06	02	04	02	06	08	07	12	10	08	06	01	-02	-02	-03	-03	-03	-04	-04
5	-04	-01	00	00	02	04	05	08	06	08	07	10	12	14	12	08	08	04	04	05	08	04	06	05
6	06	05	08	05	05	05	06	06	12	13	14	14	15	16	14	13	08	05	03	04	02	02	01	01
7	01	00	-10	-15	-12	-12	-12	02	08	20	31	38	35	33	35	39	20	10	-01	-15	-18	-21	-23	-31
8	-29	-38	-38	-44	-43	-45	-21	32	55	65	89	84	91	93	95	85	74	66	50	47	48	47	47	53
9	52	50	49	48	50	56	62	68	66	52	46	54	56	61	53	49	50	42	23	10	-03	-15	-21	-22
10	-23	-23	-23	-28	-40	-48	-51	-50	-46	-48	-48	-44	-42	-38	-39	-50	-54	-68	-78	-88	-89	-92	-95	-98
11	-95	-96	-104	-104	-106	-107	-89	-62	-50	-39	-35	-30	-24	-10	-03	-15	-14	-22	-30	-32	-32	-28	-26	-24
12	-22	-17	-15	-12	-13	-09	-04	04	04	12	26	48	60	52	47	42	40	36	41	40	42	44	44	48
13	-54	-57	-56	-56	-58	-60	-62	-72	-75	-77	-79	-83	-90	-84	-63	-38	-23	-11	00	-05	-08	-10	-16	-17
14	-14	-12	-12	-16	-16	-20	-20	-21	-22	-19	-18	-16	-11	-12	-18	-20	-23	-25	-27	-27	-29	-30	-31	-32
15	-26	-26	-26	-24	-26	-22	-18	-07	-04	02	05	14	14	15	14	10	09	04	-04	-02	00	00	-01	-01
16	-02	-02	-02	-01	-02	-03	-01	14	29	58	73	72	78	88	96	98	94	83	68	67	57	52	68	71
17	68	56	58	51	33	37	50	49	51	51	56	63	63	58	64	65	63	54	55	55	61	52	48	43
18	43	44	46	51	50	48	58	57	67	48	42	42	52	68	52	46	51	42	47	41	39	38	43	43
19	45	32	28	46	82	40	36	56	64	70	84	120	105	122	80	74	80	62	54	50	50	44	46	52
20	48	50	50	51	40	44	47	62	60	50	52	54	58	50	66	98	96	89	91	94	97	94	83	77
21	68	70	68	50	60	66	102	125	141	156	140	132	124	167	189	172	159	144	134	120	117	115	93	105
22	127	136	136	110	69	58	54	88	94	92	104	82	78	57	82	74	56	53	63	62	56	52	51	59
23	64	64	52	52	66	72	80	85	89	95	93	110	120	130	139	125	120	115	100	95	75	66	72	48
24	46	42	44	40	41	45	32	40	60	62	45	50	64	62	60	59	50	50	41	35	32	26	26	18
25	21	20	11	15	12	15	14	26	46	70	80	86	77	79	83	92	85	67	76	79	75	53	51	33
26	40	50	65	74	71	68	54	79	84	86	100	106	120	124	110	90	87	100	90	90	90	80	62	61
27	64	62	45	53	49	65	70	59	74	82	88	88	88	91	98	90	90	94	90	90	92	92	96	96
28	81	78	78	77	76	80	81	84	88	92	100	90	94	88	114	105	103	105	100	96	105	105	100	100
29	78	62	48	42	38	40	46	73	80	76	82	98	135	158	165	143	141	127	115	102	93	84	76	70
30	52	94	110	108	102	110	120	121	88	118	128	152	160	166	162	152	142	127	116	111	106	96	90	82
31																								

*Temperatures in tenths of degrees Celsius - Temperatures en dixième de degrés Celsius

MONTH/MOIS

MAY / MAI

1983

AT/A

ST. JOHN'S "A" (YTT) FELD.

LAT 47° 37' N			LONG 52° 45' W			ELEVATION ALTITUDE 140		METRES ASL / METRES (MM)			
DATE	TEMPERATURE TEMPERATURE			PRECIPITATION PRECIPITATIONS			SNOW ON GROUND NEIGE AU SOL	WIND VENT			BRIGHT SUNSHINE INSOLATION EFFECTIVE
	MAXIMUM MAXIMALE	MINIMUM MINIMALE	MEAN MOYENNE	RAINFALL PLUIE (HAUTEUR)	SNOWFALL NEIGE (HAUTEUR)	TOTAL PRECIP PRECIP TOTALE		AVERAGE SPEED VITESSE MOYENNE	PREVAILING DIRECTION DIRECTION DOMINANTE	MAXIMUM SPEED AND DIRECTION VITESSE MAXIMALE ET DIRECTION	
1	15.3	4.5	10.2	0.2		0.2		25.3	WSW	WSW 48 ^A	3.7
2	13.0	1.4	7.2	TR		TR		36.4	W	W 56 ^A	9.0
3	8.1	2.1	5.1	7.6		7.6		15.9	SE	S 32	0.0
4	12.2	0.9	7.1					13.7	SVRL	SW 26	0.2
5	20.7	10.7	15.7	1.0		1.0		25.3	SW	SW 37 ^A	0.8
6											
7	17.8	8.0	12.9	4.2		4.2		19.4	SVRL	SW 33	0.0
8	11.5	-0.6	5.5					21.0	SVRL	W 33	11.1
9	10.5	-0.5	4.5					15.9	SVRL	ESE 30 ^A	13.6
10	13.3	2.0	7.9	9.0		9.0		12.0	SE	SSE 20	2.1
	3.2	1.0	3.1	8.8		8.8		23.4	NE	NNE 32	0.0
11	5.0	0.6	2.8					26.3	E	E 30 ^A	3.0
12	4.1	0.5	2.3	8.6		8.6		21.3	E	E 30	0.0
13	18.3	3.8	11.1	0.2		0.2		7.2	E	ESE 15 ^A	7.0
14	11.3	3.6	7.5	7.4		7.4		10.7	NE	ESE 20	0.0
15	13.7	6.8	11.3	17.0		17.0		4.9	NE	SE 22	5.2
16											
17	20.1	8.9	14.5	TR		TR		12.6	WSW	WSW 24	5.8
18	14.4	7.8	11.1	0.4		0.4		12.5	SE	ESE 24 ^A	0.6
19	17.5	2.4	10.0	TR		TR		21.7	S	WSW 30 ^A	3.0
20	13.7	1.0	7.4	0		0		28.7	W	W 33 ^A	12.4
	15.2	3.2	9.2					20.9	W	WSW 37	13.6
21	16.3	8.3	12.3	1.6		1.6		41.5	SW	SW 56	1.0
22	15.3	1.7	8.5	1.6		1.6		25.5	WSW	SW 43	1.9
23	5.1	1.3	3.2	2.6		2.6		35.7	NNW	NW 46 ^A	0.2
24	5.2	1.2	3.2	1.0		1.0		27.8	N	N 44 ^A	0.0
25	5.1	0.6	2.9	0.2		0.2		9.5	E	E 19	2.4
26											
27	2.6	-0.3	1.1	TR	TR	TR		24.5	ENE	ENE 37	0.0
28	8.6	0.6	4.6					16.1	SVRL	NNE 30	11.3
29	12.2	3.3	7.8	1.4		1.4		16.0	SE	SE 26	7.2
30	6.2	3.2	4.7	11.4		11.4		23.3	E	E 32	2.0
	9.3	3.0	6.2	0.8		0.8		7.4	SVRL	E 22	2.3
31	5.2	2.3	3.8	2.2		2.2		12.7	N	N 19 ^A	0.2
MEAN MOYENNE	11.4	3.0	7.2	TOTAL 87.2	TOTAL TR	TOTAL 87.2		19.3	PREVAILING WSW	MAXIMUM W/SW 56	TOTAL 115.6
DOMINANTS											

^A Indicates more than one occurrence of same speed but not necessarily same direction.

STANDARD TIME USED. HEURE NORMALE UT/LSEE. N.S.T.																								
DRY-BULB TEMPERATURE SUMMARY* SOMMAIRE DES TEMPERATURES DU THERMOMÈTRE SEC*											MONTH MOIS		MAY / MAI						19 83					
Day	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	71	72	65	52	52	56	70	75	80	78	84	100	102	102	120	147	153	152	136	118	114	109	111	110
2	107	108	102	98	91	86	79	77	95	117	130	121	117	114	106	102	108	108	103	64	52	47	34	18
3	19	28	34	28	30	32	36	43	36	36	44	34	40	31	29	29	26	26	32	35	81	70	62	60
4	54	44	34	18	12	12	18	20	26	10	17	26	28	36	42	44	46	45	46	46	65	105	115	125
5	126	130	122	129	136	145	148	156	174	164	174	170	160	172	196	205	172	140	130	130	124	124	120	109
6	114	118	116	118	114	104	101	113	128	134	138	145	155	158	160	175	174	162	152	126	106	90	88	93
7	87	84	80	70	58	56	57	60	66	82	90	100	104	74	90	57	48	38	25	17	13	08	10	12
8	-04	16	20	06	-06	10	57	74	82	103	91	79	85	85	90	91	68	56	44	35	34	32	32	32
9	32	34	32	35	35	38	57	47	87	82	133	124	90	98	113	130	128	138	122	93	73	45	32	26
10	26	27	23	19	17	21	21	24	24	23	30	28	26	21	21	18	18	16	14	16	17	15	14	14
11	13	14	14	12	14	15	17	30	42	46	44	42	42	38	38	30	30	24	19	15	12	12	13	10
12	08	08	06	07	06	08	09	12	14	22	21	25	24	20	20	20	20	20	20	22	22	26	26	31
13	32	40	36	43	42	42	46	57	67	90	110	130	154	166	136	98	134	139	112	64	66	56	58	52
14	51	47	41	42	38	38	38	50	44	50	60	72	74	56	48	64	63	60	60	68	80	109	93	94
15	92	92	88	83	88	86	99	104	114	130	132	142	116	86	70	82	76	100	108	98	89	91	93	91
16	91	95	98	95	93	91	96	92	96	108	132	150	166	172	197	184	140	118	109	106	101	98	96	96
17	96	96	96	99	90	90	91	97	86	87	91	78	78	80	91	106	118	113	140	126	138	132	121	113
18	119	114	120	123	128	130	133	135	145	168	162	150	140	134	120	118	156	153	107	73	59	53	46	44
19	44	45	24	17	12	26	34	41	53	71	80	102	114	121	132	134	134	125	109	100	90	78	88	74
20	60	50	44	41	36	48	70	92	100	116	123	150	152	132	142	147	150	138	142	116	109	95	91	83
21	75	72	83	90	87	92	101	113	126	148	150	154	142	140	138	143	134	130	121	118	116	110	111	114
22	103	99	96	94	93	91	96	112	120	126	142	142	144	140	132	132	124	118	111	86	45	31	27	24
23	20	19	17	17	15	16	18	19	24	31	44	44	46	42	42	31	29	28	28	27	26	24	27	27
24	25	21	21	18	18	19	20	26	29	36	36	40	48	49	46	44	34	26	22	17	15	14	16	15
25	15	16	15	14	12	14	18	26	31	36	48	48	48	44	42	37	39	34	24	13	16	16	13	10
26	10	08	06	02	-02	-02	-02	-04	01	04	08	12	13	13	13	16	16	17	16	17	17	18	21	24
27	24	26	26	26	26	27	38	45	61	70	80	72	84	75	85	70	73	67	55	30	24	08	16	20
28	33	24	34	41	39	50	68	78	91	105	120	109	99	95	81	76	64	60	50	42	44	38	42	41
29	45	41	42	41	46	45	48	51	53	59	56	54	52	53	52	48	42	42	38	38	38	38	38	37
30	37	35	32	32	30	32	36	40	48	52	58	80	83	90	73	70	67	58	54	48	41	38	41	38
31	34	33	31	29	28	30	32	34	38	38	44	40	50	38	44	47	40	32	27	25	25	26	26	26

*Temperatures in tenths of degrees Celsius - Températures en dixième de degrés Celsius

*Temperatures in tenths of degrees Celsius - Températures en dixième de degrés Celsius

MONTH/MOIS

JUNE / JUIN

19 83

AT/A ST. JOHN'S "A" (YYT), NFLD.

LAT: 47° 37' N		LONG. 52° 45' W		ELEVATION: 140		METRES (ASL) METRES (NNM)					
DATE	TEMPERATURE TEMPERATURE			PRECIPITATION PRECIPITATIONS			SNOW ON GROUND NEIGE AU SOL	WIND VENT			BRIGHT SUNSHINE INSOLATION EFFECTIVE
	MAXIMUM MAXIMALE	MINIMUM MINIMALE	MEAN MOYENNE	RAINFALL PLUIE (HAUTEUR)	SNOWFALL NEIGE (HAUTEUR)	TOTAL PRECIP PRÉCIP. TOTALE		AVERAGE SPEED VITESSE MOYENNE	PREVAILING DIRECTION DIRECTION DOMINANTE	MAXIMUM SPEED AND DIRECTION VITESSE MAXIMALE ET DIRECTION	
	°C	°C	°C	mm	cm	mm		cm	km/h	km/h	
1	13.8	2.5	8.2	3.0		3.0		25.4	SE	SE 37	0.0
2	15.8	9.6	12.7	17.6		17.6		38.4	S	S 67	0.0
3	15.8	6.2	11.0					37.6	WSW	WSW 54	9.8
4	20.7	5.1	12.9					29.2	WSW	WSW 46	13.7
5	14.9	8.7	11.8	12.0		12.0		27.0	SVRL	SW 56	0.0
6	12.6	6.0	9.3					9.2	S	S 15	9.5
7	17.4	6.9	12.2	4.2		4.2		13.9	S	S 28	4.7
8	19.7	8.8	14.3	8.2		8.2		26.7	WSW	WSW 33	2.2
9	20.6	5.7	13.2	1.4		1.4		24.8	WSW	WSW 37	10.4
10	20.9	5.5	13.2					20.1	WSW	W 32	12.5
11	10.3	5.0	7.7	23.4		23.4		15.8	SVRL	N 26	0.0
12	16.8	5.4	11.1					22.5	WSW	W 33	7.3
13	10.5	-0.7	4.9					0.5	SVRL	NNE 28	8.5
14	5.4	0.1	2.8					17.7	NNE	NNE 24	5.7
15	6.3	0.2	3.3					13.3	N	N 20	7.8
16	14.5	-0.3	7.2	TR		TR		24.9	WSW	WSW 33	0.4
17	13.8	0.3	7.1	2.0		2.0		20.2	W	WSW 32	3.1
18	27.4	8.0	17.2	TR		TR		25.4	WSW	W 32	10.1
19	29.3	11.4	20.4	0		0		31.4	WSW	WSW 39	11.1
20	19.0	7.4	13.2	2.8		2.8		19.0	WSW	WSW 33	0.0
21	11.2	5.4	8.3	1.8		1.8		12.8	NE	NE 19	0.7
22	11.1	4.8	8.0	0.4		0.4		12.7	SVRL	NNE 19	0.0
23	20.4	9.6	15.0					13.2	SW	WSW 19	10.4
24	18.9	8.9	13.9					19.0	S	SSE 28	10.8
25	21.9	9.4	15.7	4.0		4.0		10.3	SSE	SSE 22	5.8
26	17.4	10.0	13.7	3.6		3.6		LGT.			
27	20.5	10.4	15.5					5.8	VRBL	WSW 15	1.6
28	18.7	5.3	12.0	1.4		1.4		8.0	SSE	SSE 17	6.5
29	17.7	7.9	12.8					17.5	WSW	WSW 33	7.2
30	23.7	9.5	16.6					22.1	WSW	WSW 33	14.6
31								31.0	WSW	SW 43	14.4
MEAN MOYENNE	16.9	6.1	11.5	TOTAL 85.8	TOTAL 0	TOTAL 85.8		20.4	PREVAILING WSW	MAXIMUM S 67	TOTAL 188.8

△ Indicates more than one occurrence of same speed but not necessarily same direction.

STANDARD TIME USED: HEURE NORMALE UTILISEE: N.S.T.																								
DRY-BULB TEMPERATURE SUMMARY* SOMMAIRE DES TEMPERATURES DU THERMOMETRE SEC*											MONTH MOIS		JUNE / JUIN						19 83					
Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	28	26	25	26	26	30	34	38	43	45	44	48	56	60	60	64	64	66	66	74	81	128	121	113
2	121	136	135	141	145	148	148	152	148	154	152	156	154	158	153	158	134	128	122	114	110	107	110	113
3	114	133	116	86	69	79	76	82	92	96	112	138	138	148	151	148	146	145	124	100	84	79	80	70
4	69	64	65	68	60	97	115	150	164	174	185	182	196	184	185	182	179	165	150	138	124	112	106	104
5	102	104	104	104	105	106	112	116	106	109	104	101	114	121	142	145	127	122	118	108	104	102	95	90
6	90	88	88	74	60	32	79	77	96	111	118	118	126	117	114	119	108	96	94	100	88	79	75	72
7	70	71	80	72	75	73	89	106	112	131	164	168	164	163	122	136	164	162	152	135	127	123	127	138
8	130	138	160	161	152	142	138	146	160	190	184	170	176	193	180	166	162	152	147	140	128	104	93	88
9	89	90	89	90	92	98	96	98	102	122	142	152	166	179	198	206	171	145	119	101	89	84	76	69
10	63	65	57	61	62	79	96	115	125	142	156	171	181	180	207	205	179	170	153	138	126	115	114	110
11	109	104	103	100	76	74	79	80	80	63	62	60	62	66	61	58	55	56	54	53	56	58	53	56
12	57	56	64	70	72	80	97	99	106	113	121	129	131	135	149	147	164	145	152	138	115	104	104	96
13	86	79	75	62	60	74	82	100	98	104	94	95	91	78	56	50	38	32	24	18	14	02	-05	-05
14	00	14	12	10	10	08	11	17	25	31	36	42	48	48	47	50	36	34	24	16	12	10	10	09
15	07	08	04	04	06	12	11	22	24	27	31	43	48	54	63	56	52	52	41	40	27	05	13	33
16	37	49	54	59	62	70	80	90	96	110	141	130	63	52	43	47	48	37	30	26	24	26	20	09
17	09	-02	03	10	12	30	46	52	67	78	88	105	115	128	138	124	112	92	84	71	76	71	68	63
18	70	76	82	87	90	97	110	119	128	160	195	229	232	247	269	271	240	225	203	184	163	161	165	152
19	140	137	132	128	121	114	118	122	197	202	224	241	263	267	288	289	260	224	196	180	171	162	154	149
20	144	144	138	140	148	154	147	172	180	178	185	174	170	165	182	132	122	124	114	126	138	133	128	128
21	110	82	74	72	68	71	74	74	75	78	86	92	93	104	98	101	91	83	64	58	53	58	58	55
22	56	56	54	49	49	53	55	62	65	76	83	89	99	107	82	87	95	102	104	94	100	101	100	100
23	102	96	98	100	105	110	126	128	154	172	178	190	196	200	194	194	190	180	169	160	136	117	113	112
24	104	102	96	90	101	114	120	134	165	184	152	172	174	168	152	170	178	178	154	137	128	127	135	116
25	112	118	110	102	101	98	96	102	110	140	143	156	172	192	204	212	216	194	177	162	148	141	130	121
26	114	108	106	106	103	108	109	118	126	136	154	154	164	172	168	146	146	141	114	122	119	106	107	103
27	105	108	108	113	110	108	120	130	140	149	158	162	182	188	186	204	200	194	178	167	162	152	148	148
28	150	146	137	136	134	121	120	126	131	122	127	134	158	166	172	183	184	175	166	144	126	114	96	80
29	62	56	79	76	76	84	106	110	119	136	145	163	163	162	173	174	170	167	154	138	130	120	107	100
30	96	100	102	103	103	116	132	147	165	196	207	222	228	230	234	232	228	214	199	178	162	152	151	140
31																								

*Temperatures in tenths of degrees Celsius - Températures en dixième de degrés Celsius

MONTH/MOIS

JULY / JUILLET

19 83

AT/A

ST. JOHN'S "A", NFLD.

LAT		47° 37' N		LONG		52° 45' W		ELEVATION		140		METRES (ASL)		METRES (NMM)	
DATE	TEMPERATURE			PRECIPITATION			SNOW ON GROUND NEIGE AU SOL	WIND			BRIGHT SUNSHINE INSOLATION EFFECTIVE HOURS HEURES				
	MAXIMUM MAXIMALE	MINIMUM MINIMALE	MEAN MOYENNE	RAINFALL PLUIE (HAUTEUR)	SNOWFALL NEIGE (HAUTEUR)	TOTAL PRECIP PRECIP TOTALE		AVERAGE SPEED VITESSE MOYENNE	PREVAILING DIRECTION DOMINANTE	MAXIMUM SPEED AND DIRECTION VITESSE MAXIMALE ET DIRECTION					
	°C	°C	°C	mm	cm	mm		km/h		km/h					
1	25.0	12.9	19.0					26.5	SW	WSW 37	12.3				
2	22.7	6.6	14.7	0.2	0	0.2		36.2	WSW	WSW 56Δ	9.4				
3	8.3	6.6	7.5	11.1		11.1		12.4	ENE	ENE 22Δ	0.0				
4	16.2	6.5	11.4					8.4	WSW	WSW 26	3.0				
5	27.2	10.7	19.0					34.2	WSW	WSW 41	12.1				
6	31.5	16.0	23.8					34.0	WSW	WSW 46	9.4				
7	26.2	13.3	22.5	TR		TR		27.1	WSW	WSW 33Δ	7.2				
8	20.3	9.4	14.9	22.0		22.0		17.8	SVRL	S 33	0.9				
9	18.8	9.2	14.0					12.5	SE	SE 28	8.9				
10	16.7	11.4	14.1	7.4		7.4		15.0	SSE	SSE 30Δ	0.0				
11	21.6	12.5	17.1	3.6		3.6		12.4	S	S 22▲	1.2				
12	20.6	14.0	17.3	1.4		1.4		17.4	SE	SE 33	2.4				
13	23.7	14.8	19.3	1.2		1.2		15.9	S	S 24	11.2				
14	21.5	13.8	17.7	TR		TR		13.0	SE	SSE 24	4.8				
15	19.5	14.2	16.9	5.3		5.3		19.0	SE	SSE 28	0.0				
16	23.5	15.5	19.5	2.9		2.9		17.6	SSE	SE 30	9.0				
17	21.2	14.6	17.9	5.4		5.4		27.3	SVRL	S 37▲	3.4				
18	20.5	12.6	16.6					36.6	WSW	SW 52▲	13.7				
19	25.1	11.8	18.5					31.6	WSW	WSW 44	13.4				
20	15.6	9.8	12.7	TR		TR		14.0	ESE	W 29	2.1				
21	19.7	12.2	16.0	TR		TR		14.1	S	S 30	6.5				
22	23.4	13.4	18.4	22.6		22.6		21.1	WSW	WSW 43	11.5				
23	23.0	14.3	18.9	2.0		2.0		28.9	S	SSW 44	5.1				
24	18.9	11.3	15.1	TR		TR		24.3	SW	SSW 41	11.3				
25	14.7	8.0	11.4	25.4		25.4		7.3	E	ENE 19	2.1				
26	19.7	10.0	14.9	4.2		4.2		17.9	S	W 37	1.4				
27	18.9	9.5	14.2	TR		TR		14.3	SVRL	WNW 33	6.1				
28	19.6	9.2	14.4	TR		TR		15.1	S	S 24	10.7				
29	23.4	14.4	18.9	0.6		0.6		26.5	SW	WSW 37	3.3				
30	23.8	16.3	20.1	4.6		4.6		38.7	WSW	SW 56	2.7				
31	22.4	6.5	14.5	1.0		1.0		31.3	WSW	SSW 50	9.5				
MEAN MOYENNE	21.1	11.8	16.5	TOTAL 121.4	TOTAL	TOTAL 121.4		21.6	WSW DOMINANTE	WSW 56	TOTAL 191.7				

Δ Indicates more than one occurrence of same speed but not necessarily same direction.

STANDARD TIME USED: HEURE NORMALE UTILISEE N.S.T.																								
DRY-BULB TEMPERATURE SUMMARY* SOMMAIRE DES TEMPERATURES DU THERMOMETRE SEC*											MONTH MOIS		JULY / JUILLET						19 83					
Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	141	143	141	133	137	148	177	183	206	227	240	241	236	249	247	243	234	227	206	180	170	163	162	162
2	153	132	132	142	152	174	160	164	181	199	204	204	210	222	210	188	185	170	153	148	146	126	86	75
3	68	70	68	67	67	72	70	70	72	74	74	78	76	80	75	77	76	78	71	71	70	70	70	70
4	70	70	70	70	72	76	80	86	90	98	108	128	126	140	145	160	151	128	131	156	141	128	117	112
5	114	110	108	108	123	125	136	150	160	172	207	216	242	254	268	259	269	250	230	210	195	186	181	174
6	162	163	169	176	176	177	186	190	207	202	224	245	271	285	302	302	275	248	234	222	216	212	200	206
7	194	194	197	198	198	196	206	213	211	212	246	236	246	262	262	262	262	246	235	215	198	190	190	192
8	196	200	200	198	196	196	192	187	188	183	190	202	194	180	194	156	147	140	128	130	140	120	120	121
9	102	96	96	95	95	98	96	106	116	123	150	174	184	179	164	163	168	168	155	126	108	108	114	118
10	120	121	117	120	124	128	138	139	142	139	134	145	144	142	148	146	147	144	140	128	127	126	126	127
11	121	118	165	165	162	168	170	175	178	184	193	206	212	200	190	186	194	192	192	186	172	157	151	145
12	130	126	144	157	146	142	151	142	151	162	167	185	191	200	191	184	162	158	158	164	160	158	159	164
13	164	159	157	152	160	166	177	195	190	191	192	226	200	207	237	217	218	205	198	184	172	174	168	158
14	157	154	156	161	152	147	155	156	138	160	168	183	208	198	188	177	186	182	178	168	162	148	140	139
15	155	148	150	146	144	146	146	160	168	168	166	174	180	178	192	176	166	166	158	150	150	154	155	163
16	158	164	165	160	163	164	164	167	178	184	212	216	226	228	227	231	202	208	203	186	172	163	170	163
17	164	159	161	161	158	161	161	166	170	170	170	165	192	202	208	184	170	172	170	162	160	160	156	158
18	158	154	146	150	140	138	145	160	175	185	188	195	197	204	197	192	186	181	170	150	144	143	132	128
19	134	130	132	132	130	138	146	166	180	195	206	207	224	238	245	241	241	228	214	195	180	166	166	155
20	140	125	120	115	112	104	111	116	122	128	143	150	144	150	142	132	124	122	120	114	113	115	115	117
21	113	113	119	126	127	126	124	129	132	145	156	165	170	184	188	176	178	167	150	141	144	155	155	155
22	156	154	155	148	146	146	143	151	164	174	196	204	204	208	222	214	192	178	161	146	141	138	139	140
23	138	146	149	188	191	196	191	198	205	217	216	210	220	226	210	198	188	187	185	175	167	168	164	161
24	156	156	156	153	153	151	158	142	156	164	180	178	188	186	160	166	160	146	148	134	126	123	120	118
25	120	117	115	99	87	99	118	140	138	120	130	140	138	144	138	134	132	130	134	132	136	138	139	136
26	134	134	137	138	152	153	164	160	157	164	172	173	178	194	184	180	180	170	156	156	163	156	126	112
27	102	100	102	105	109	112	132	146	153	166	160	144	165	182	148	135	118	106	112	110	102	106	106	102
28	100	98	96	98	98	96	109	127	150	164	180	173	170	185	188	182	176	176	172	160	152	148	152	148
29	152	156	152	150	152	158	161	175	182	193	206	216	218	223	226	232	232	224	210	194	188	184	176	178
30	172	168	170	168	166	172	178	194	195	200	192	208	221	231	234	212	198	170	172	171	182	184	189	188
31	186	186	186	180	177	180	174	176	178	190	208	210	204	216	214	214	204	200	142	127	117	94	90	90

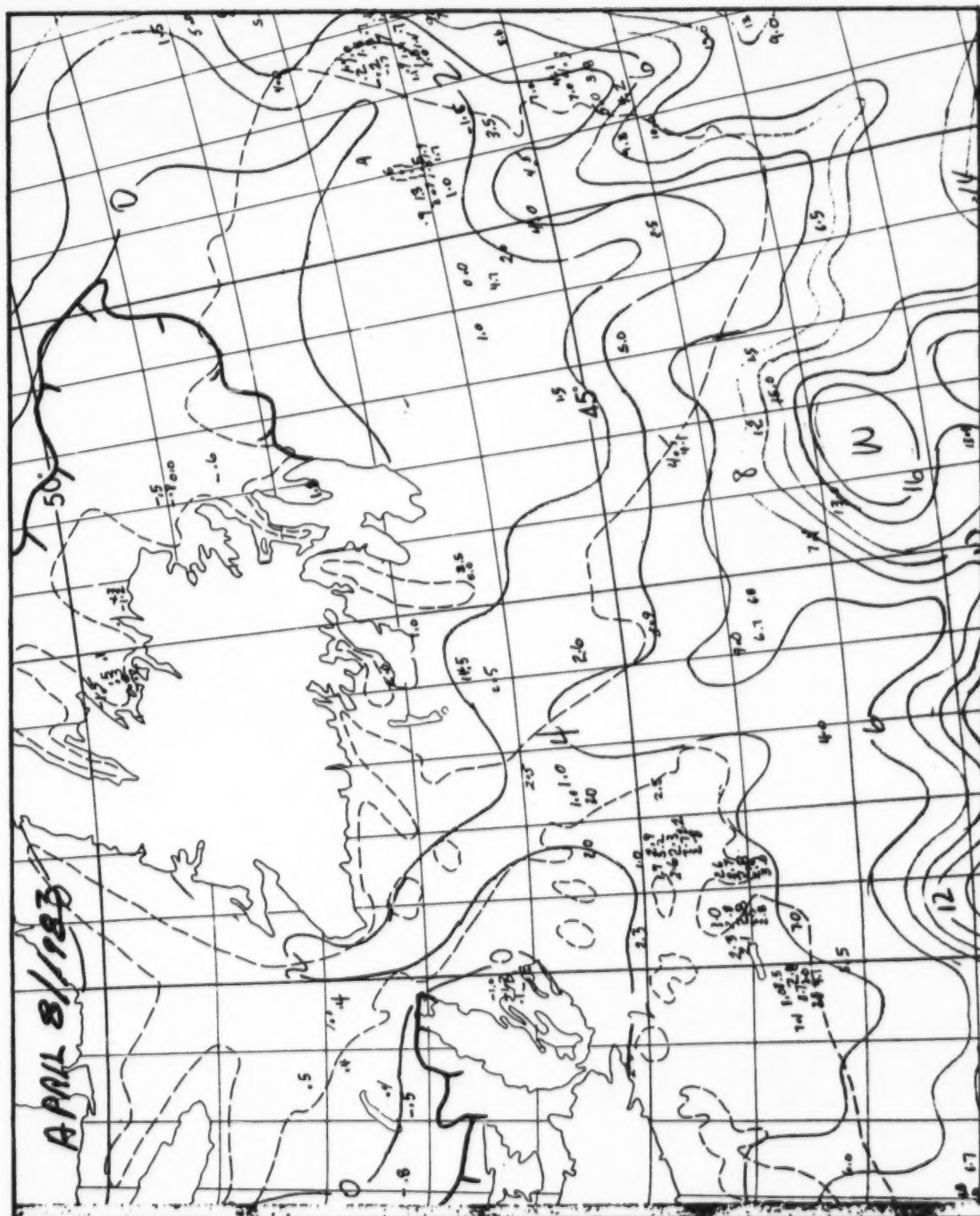
*Temperatures in tenths of degrees Celsius — Températures en dixième de degrés Celsius

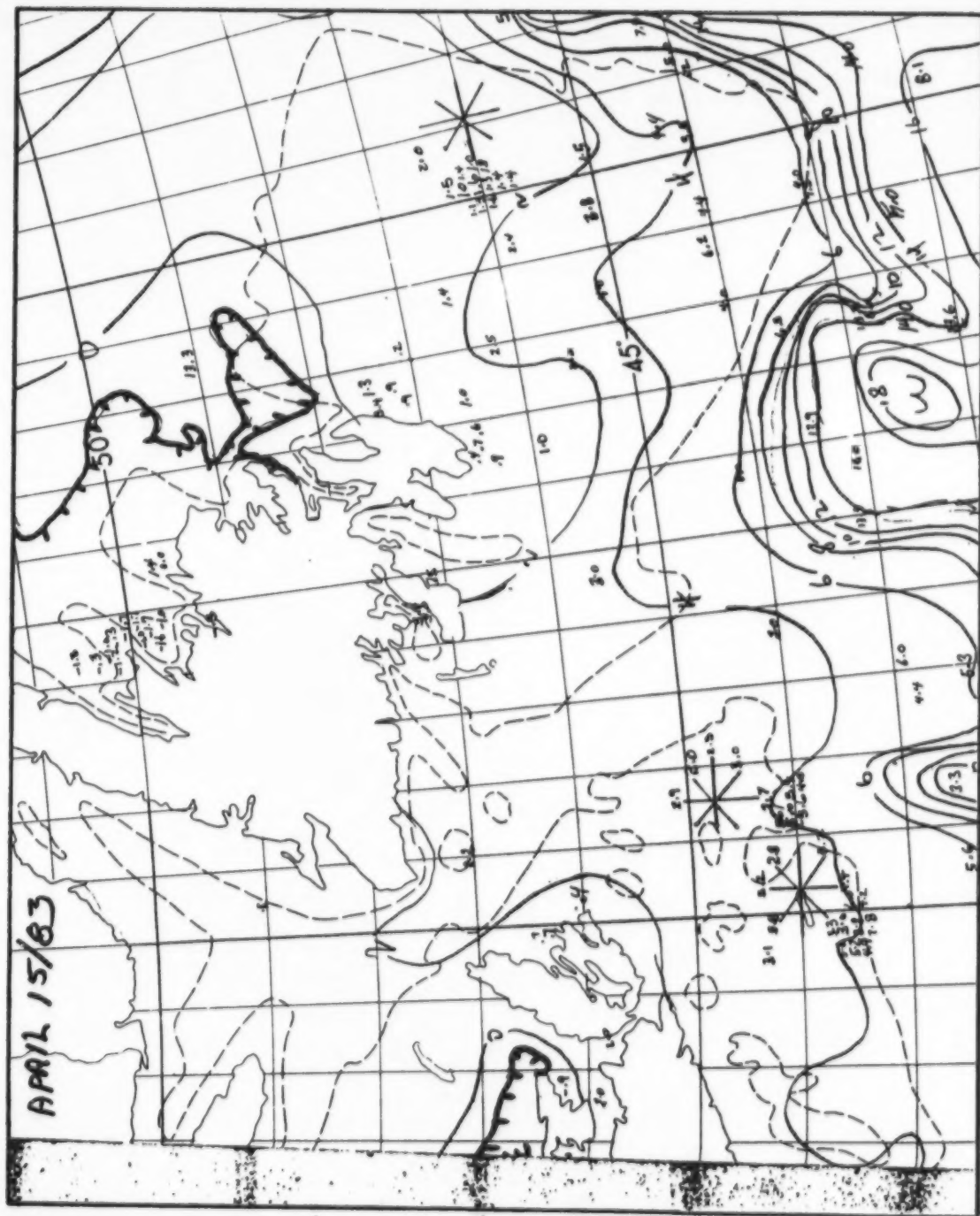
*Temperatures in tenths of degrees Celsius - Températures en dixième de degrés Celsius

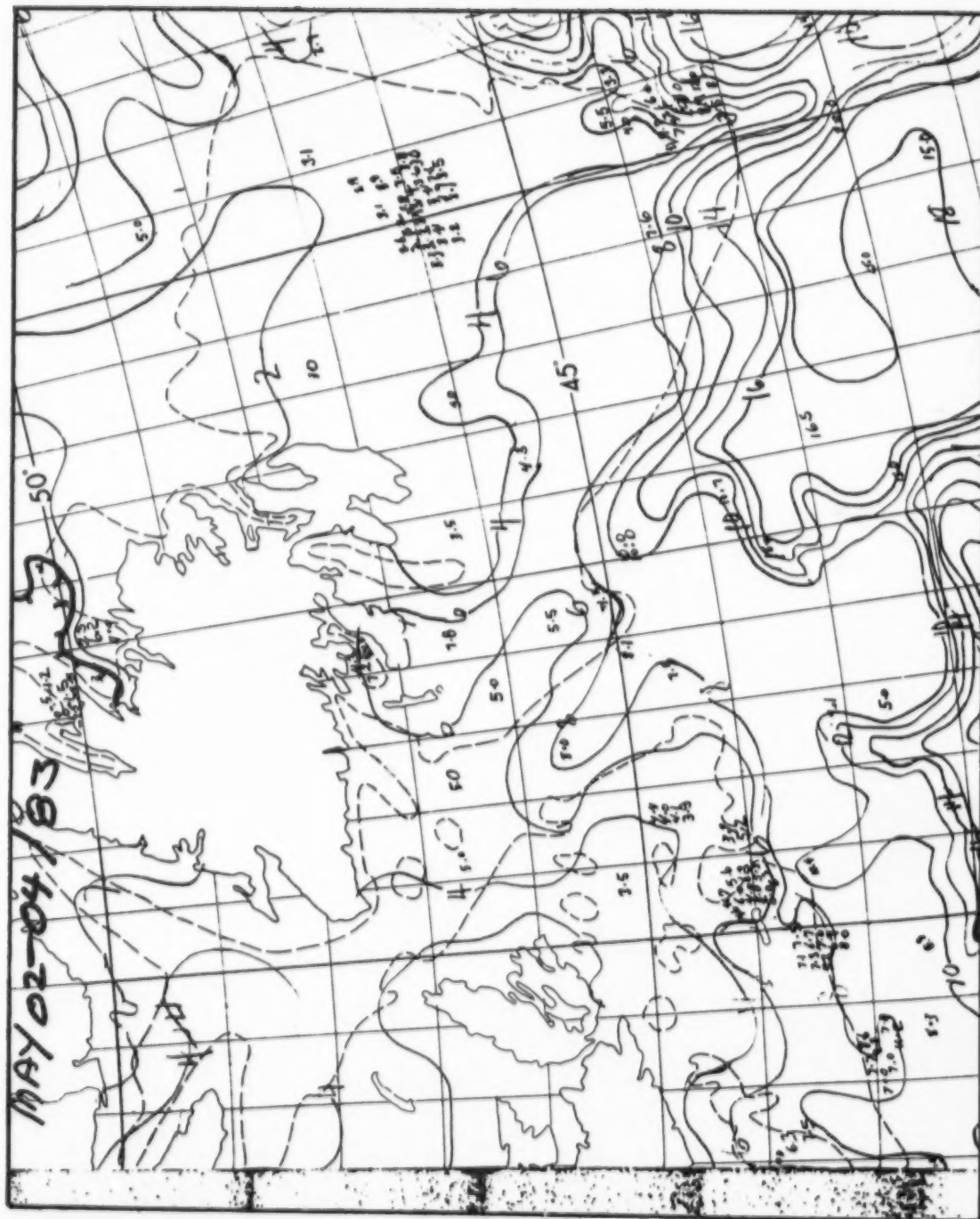
Appendix C

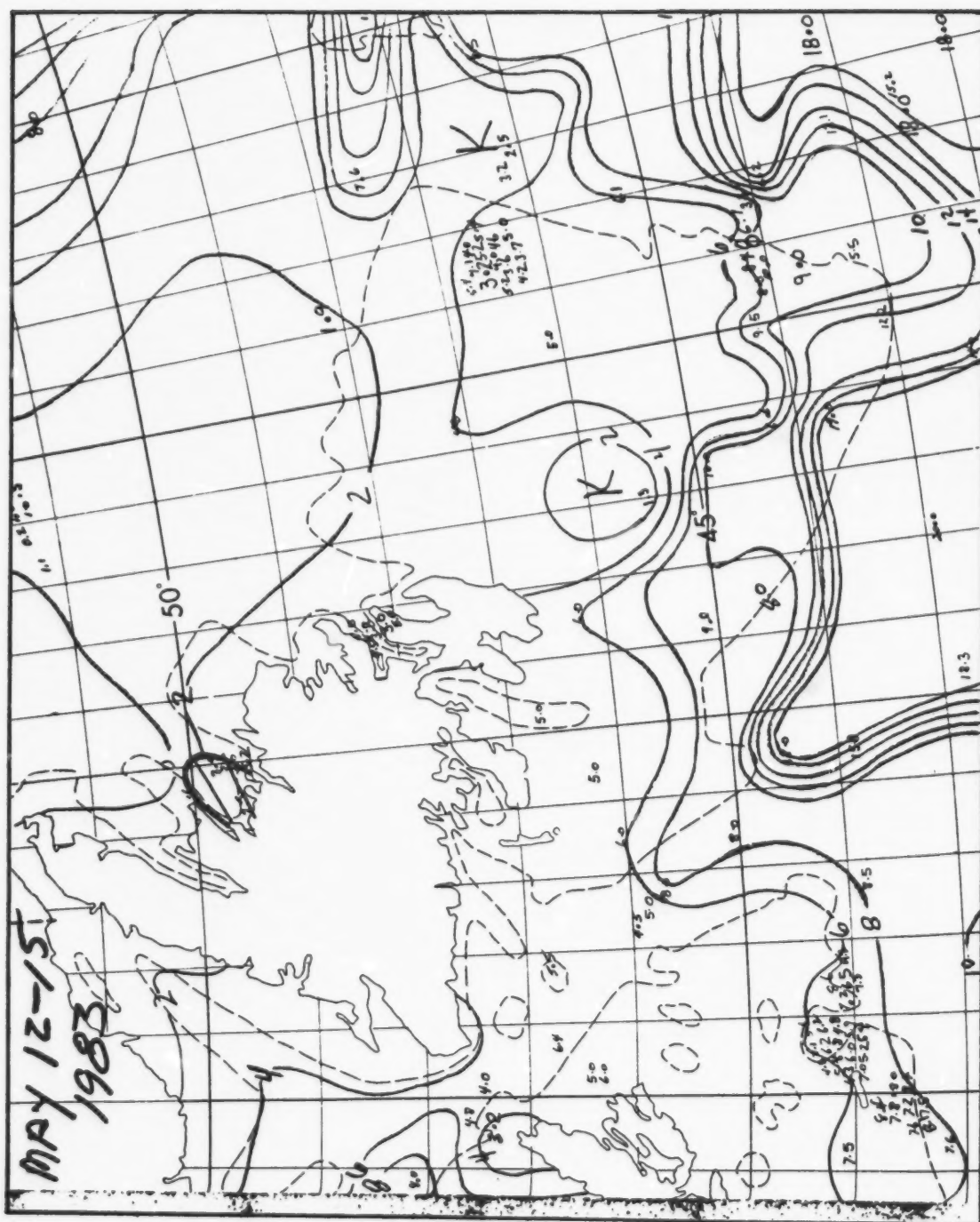
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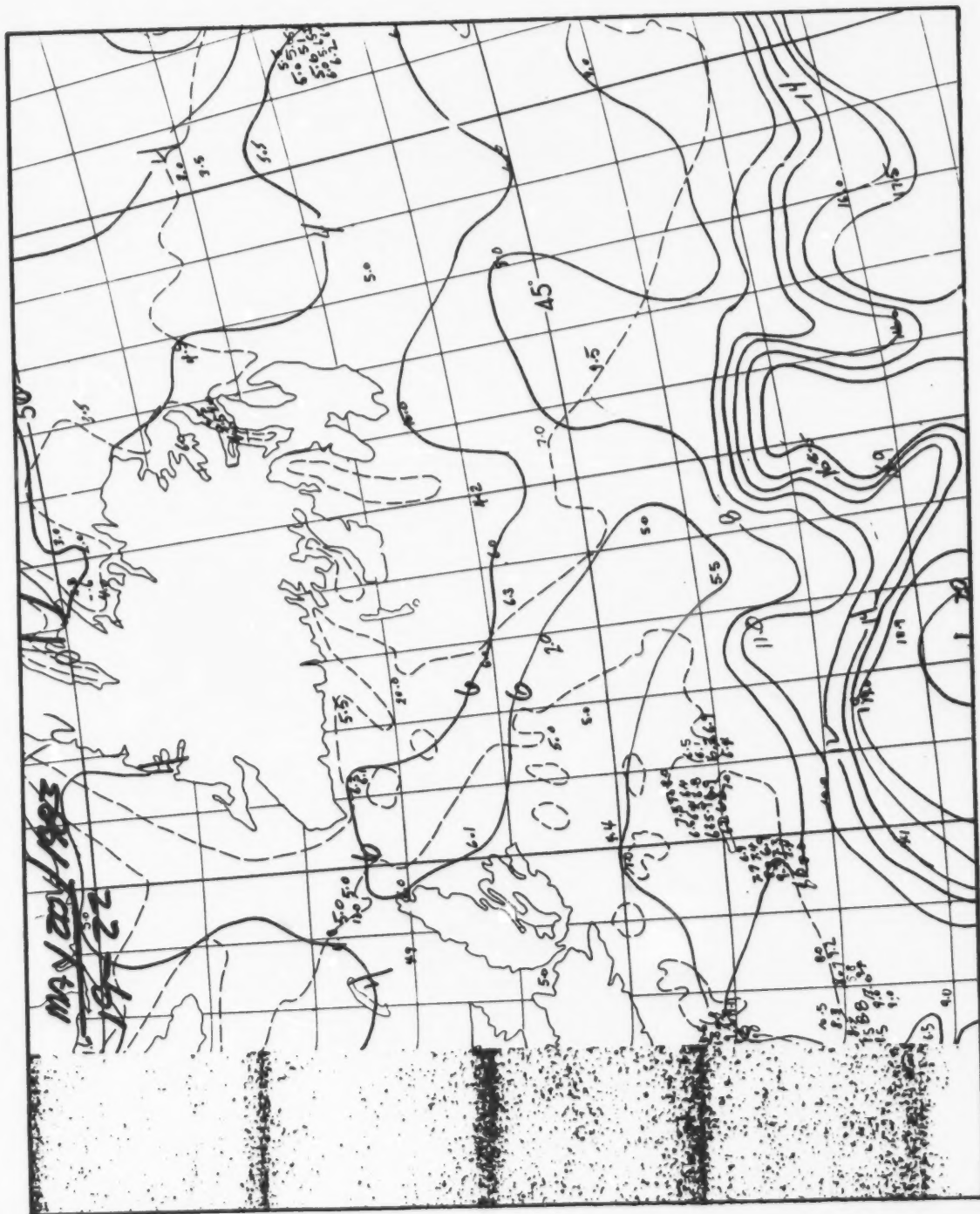
Sea Surface Temperature Readings

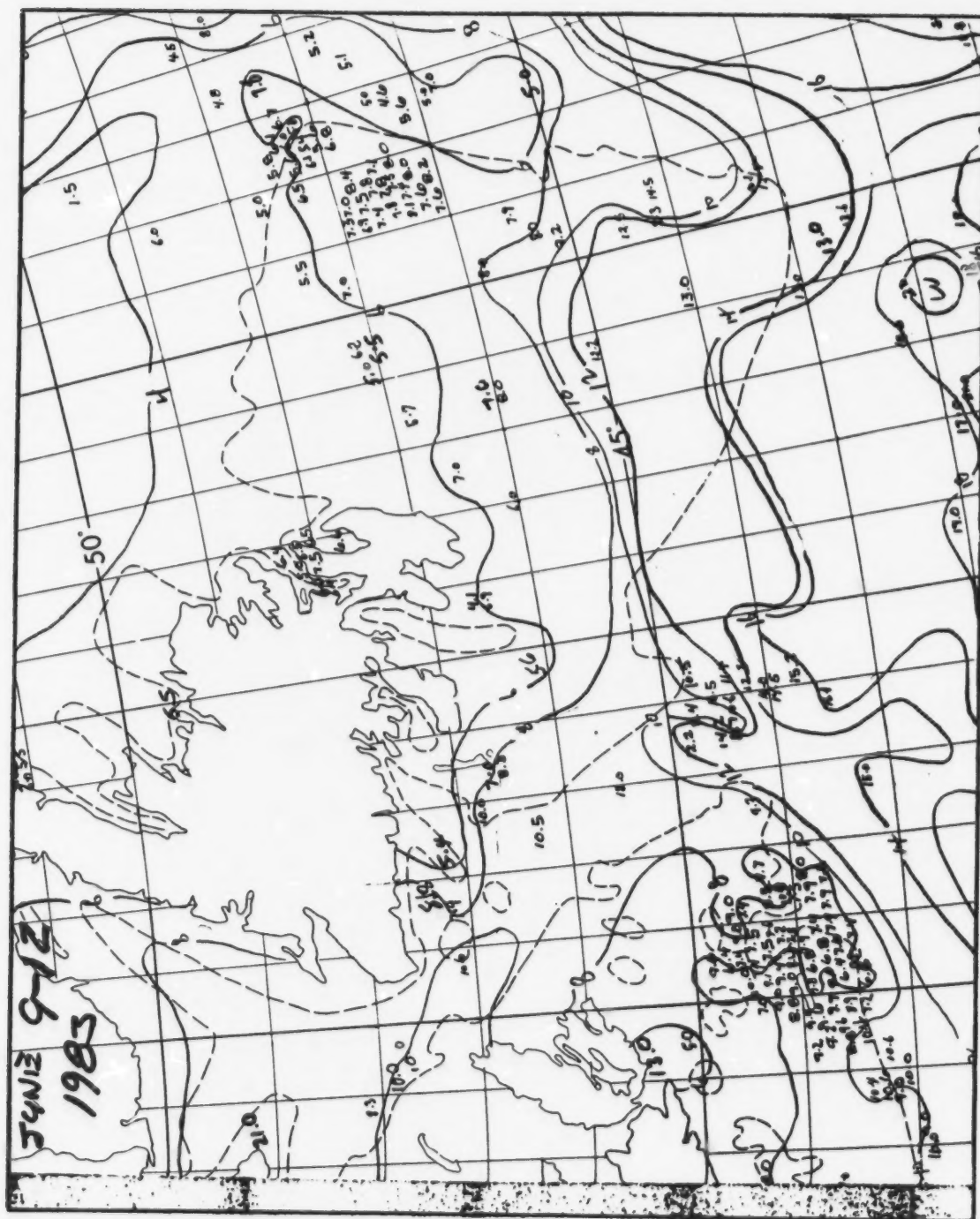


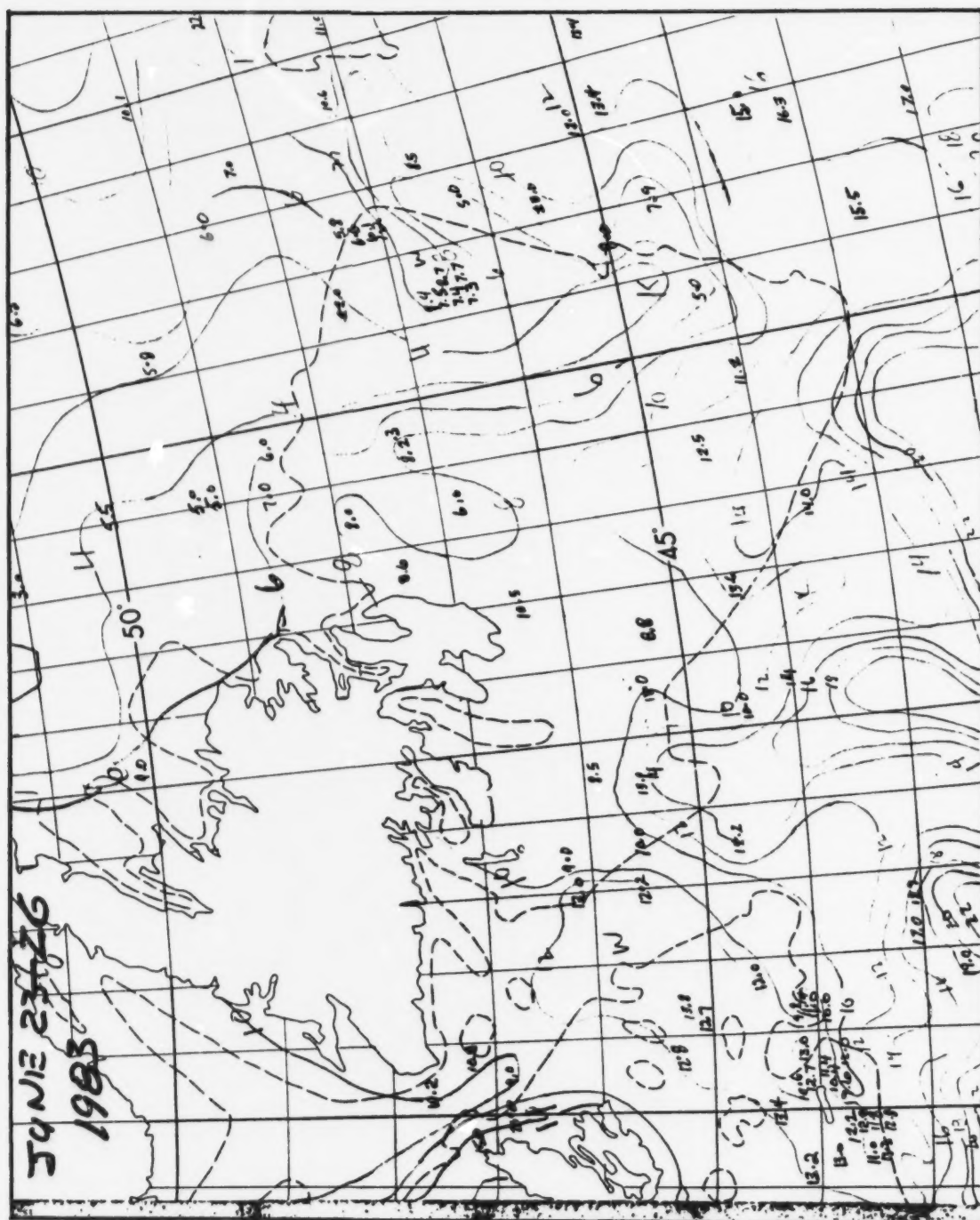












Appendix D
Resistance vs. Temperature Tables
for Thermistors Used in This Study

YSI-44005

RESISTANCE VERSUS TEMPERATURE									
TEMP°C RES		TEMP°C RES		TEMP°C RES		TEMP°C RES		TEMP°C RES	
-50	201.1K	-20	29.13K	+ 10	5971	+ 40	1598	+ 70	525.4
49	187.3K	19	27.49K	11	5892	41	1535	71	507.8
48	174.5K	18	25.95K	12	5427	42	1475	72	490.9
47	162.7K	17	24.51K	13	5177	43	1418	73	474.7
46	151.7K	16	23.18K	14	4939	44	1363	74	459.0
45	141.6K	15	21.89K	15	4714	45	1310	75	444.0
44	132.2K	14	20.70K	16	4500	46	1260	76	429.5
43	123.5K	13	19.58K	17	4297	47	1212	77	415.6
42	115.4K	12	18.52K	18	4105	48	1167	78	402.2
41	107.9K	11	17.53K	19	3922	49	1123	79	389.3
-40	101.0K	-10	16.60K	+ 20	3748	+ 50	1081	+ 80	376.9
39	94.48K	9	15.72K	21	3583	51	1040	81	364.9
38	88.46K	8	14.90K	22	3428	52	1002	82	353.4
37	82.87K	7	14.12K	23	3277	53	965.0	83	342.2
36	77.68K	6	13.39K	24	3135	54	929.6	84	331.5
35	72.81K	5	12.70K	25	3000	55	895.8	85	321.2
34	68.30K	4	12.05K	26	2872	56	863.3	86	311.3
33	64.09K	3	11.44K	27	2750	57	832.2	87	301.7
32	60.17K	2	10.86K	28	2633	58	802.3	88	292.4
31	56.51K	1	10.31K	29	2523	59	773.7	89	283.5
-30	53.10K	0	9796	+ 30	2417	+60	746.3	+90	274.9
29	49.91K	+ 1	9310	31	2317	61	719.9	91	266.6
28	46.94K	2	8851	32	2221	62	694.7	92	258.6
27	44.16K	3	8417	33	2130	63	670.4	93	250.9
26	41.58K	4	8006	34	2042	64	647.1	94	243.4
25	39.13K	5	7618	35	1959	65	624.7	95	236.2
24	36.86K	6	7252	36	1880	66	603.3	96	229.3
23	34.73K	7	6905	37	1805	67	582.6	97	222.6
22	32.74K	8	6576	38	1733	68	562.8	98	216.1
21	30.87K	9	6265	39	1664	69	543.7	99	209.8

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RESISTANCE VERSUS TEMPERATURE									
TEMP°C RES		TEMP°C RES		TEMP°C RES		TEMP°C RES		TEMP°C RES	
-50	335.3K	-20	48.56K	+ 10	9951	+ 40	2663	+ 70	875.7
49	312.3K	19	45.83K	11	9486	41	2559	71	846.4
48	291.0K	18	43.27K	12	9046	42	2459	72	818.3
47	271.3K	17	40.86K	13	8628	43	2363	73	791.2
46	253.0K	16	38.61K	14	8232	44	2272	74	765.1
45	236.2K	15	36.49K	15	7857	45	2184	75	740.0
44	220.5K	14	34.50K	16	7500	46	2101	76	715.9
43	205.9K	13	32.63K	17	7162	47	2021	77	692.7
42	192.5K	12	30.88K	18	6841	48	1944	78	670.3
41	180.0K	11	29.23K	19	6538	49	1871	79	648.8
-40	168.3K	-10	27.67K	+ 20	6247	+ 50	1801	+ 80	626.1
39	157.5K	9	26.21K	21	5972	51	1734	81	606.2
38	147.5K	8	24.83K	22	5710	52	1670	82	586.9
37	138.2K	7	23.54K	23	5462	53	1608	83	570.4
36	129.5K	6	22.32K	24	5225	54	1549	84	555.6
35	121.4K	5	21.17K	25	5000	55	1493	85	535.4
34	113.9K	4	20.08K	26	4787	56	1439	86	518.8
33	106.9K	3	19.06K	27	4583	57	1387	87	502.6
32	100.3K	2	18.10K	28	4389	58	1337	88	487.4
31	94.22K	1	17.19K	29	4204	59	1290	89	472.6
-30	88.53K	0	16.33K	+ 30	4029	+60	1244	+90	458.2
29	83.22K	+ 1	15.52K	31	3861	61	1200	91	444.4
28	78.26K	2	14.75K	32	3702	62	1158	92	431.0
27	73.62K	3	14.03K	33	3549	63	1117	93	418.2
26	69.29K	4	13.34K	34	3404	64	1079	94	405.7
25	65.24K	5	12.70K	35	3266	65	1041	95	393.7
24	61.45K	6	12.09K	36	3134	66	1006	96	382.1
23	57.90K	7	11.51K	37	3008	67	971.1	97	370.9
22	54.58K	8	10.96K	38	2886	68	936.0	98	360.1
21	51.47K	9	10.44K	39	2773	69	906.3	99	349.7